

COLLECTION OF THE GoNANO WHITE PAPERS

*SUGGESTION FOR REALISING RRI CONDITIONS IN
NANOTECHNOLOGY RESEARCH AND INNOVATION*

| | |
|------------------------|---|
| Work Package: | WP5 |
| Deliverable number: | 5.3 |
| Partner responsible: | OeAW |
| Compiling author(s): | Ulrike Bechtold, Daniela Fuchs, Vera Borrmann (Austrian Academy of Sciences) |
| Contributor(s): | David Azoulay (Centre for International Environmental Law); Andrea Porcari, Daniela Pimponi and Elvio Mantovani (Airi - Italian Association for Industrial Research); Andrea Porcari (Airi), Maud Bomert, Hannie van den Bergh and Daan Schuurbiers (De Proeffabriek); Vanessa Moore (European Institute of Women's Health); Clare Shalley-Egan and Harald Throne-Holst (Oslo Metropolitan University); Craig Richmond (RMIT Europe); Lenka Hebáková, Marek Pour, Iva Vancurova (Technology Centre of the Czech Academy of Sciences); Sikke Jensma and Anne Dijkstra (University of Twente); Lise Bitsch and Helle Henriksen (Danish Board of Technology Foundation). |
| Quality assurance: | Lise Bitsch (Danish Board of Technology Foundation) |
| Planned delivery date: | 31 May 2020 |
| Actual delivery date: | 30 June 2020 |
| Dissemination level: | PU |

CONTENT

| | |
|--|-----|
| Executive summary | 4 |
| 1. Introduction..... | 5 |
| 1.1. Purpose, scope and structure: Role of the white papers within GoNano..... | 5 |
| 1.2. The process of developing the GoNano white papers | 6 |
| 2. Introduction to the topic: Important aspects for aligning co-creation with nanotechnology research..... | 9 |
| References..... | 9 |
| 3. The GoNano white paper series | i |
| 3.1. White Paper 1 | iii |
| 3.2. White Paper 2 | iv |
| 3.3. White Paper 3..... | v |
| 4. Annexes | vi |

EXECUTIVE SUMMARY

This report presents the GoNano white papers and their development process.

It is Deliverable 5.3 of Work Package 5 “Governance and Policy Outreach and Alignment” (Task 5.2: “white papers with policy recommendations”) of the GoNano project and serves to ensure alignment of GoNano activities with specific stakeholder groups and an interested, wider public, specifically regarding the design of the GoNano policy and industry briefs (WP5, T5.3 and T5.4). The aim is to feedback GoNano outcomes towards the regulatory and policy as well as research context and to disseminate the GoNano activities tailored to specific questions among specific stakeholder groups.

This Deliverable presents the development process and the collection of the final three GoNano white papers:

- Responsiveness in practice: aligning nanotechnology research and innovation with societal needs
- Co-creation in practice: enabling multistakeholder collaboration in nanotechnology research and innovation
- The importance of gender and diversity in nanotechnology Research and Innovation

1. INTRODUCTION

This report is Deliverable 5.3 “Three white papers with suggestion for realising RRI conditions in nanotechnology research and innovation” of Work Package 5 “Governance and Policy Outreach and Alignment” (Task 5.2: “white papers with policy recommendations”) of GoNano.

It contributes to the GoNano objectives of (1) developing concrete policy recommendations for governance of research and innovation in nanotechnology for increased responsiveness to societal needs and values; and (2) feeding back governance recommendations widely to policymakers, industry, research and innovation partnerships and consumer groups. (DoA, p. 34)

The white papers, and thus this report, build on the extensive background research that GoNano is based upon, as well as experiences of methodology development and demonstration by the pilot studies. Key policy questions were identified from the material which are then synthesized with the white paper topics. The white papers, again, build the foundation for policy, as well as industry briefs which are to be developed within the project to ensure outreach to all major stakeholder groups in order to provide them with best information on co-creation.

1.1. PURPOSE, SCOPE AND STRUCTURE: ROLE OF THE WHITE PAPERS WITHIN GoNANO

Accordingly, the Deliverable presents the three GoNano white papers and their development process in detail. The GoNano white paper series covers distinct aspects of co-creation in research and innovation, with a focus on nanotechnology. The white papers are intended as a knowledge repository for further GoNano communication activities, i.e. the deriving policy briefs (GoNano D5.5, forthcoming). As such, the white papers provide relevant background information with condensed GoNano findings and also form the basis for industry and policy briefs, outlining the topics with highest industry and policy relevance. The GoNano white papers are a core part of the GoNano project¹.

The present report is structured as follows:

- Chapter one is dedicated to rooting the white paper series within the overall GoNano context (section 1.1) and provides the reader with details on the development process throughout the GoNano project (section 1.2).
- Chapter two will shortly introduce the overall frame of the white papers
- Chapter three, finally, will then provide the reader with the final white papers.

¹ For more information on the overall structure of the project and our further understanding of co-creation see <http://gonano-project.eu/> (30-06-2020).

1.2. THE PROCESS OF DEVELOPING THE GONANO WHITE PAPERS

The GoNano white papers set out to integrate methodological aspects, empirical findings and lessons learned regarding specific topics of high priority. Their overall aim is to distill hands-on recommendations from the abundance of empirical findings from the co-creation processes that were carried out in the pilot studies.

The GoNano white papers represent an accumulation of major research outcomes by which GoNano aims at contributing to the discussion on:

- The challenge to increase the responsiveness of scientists and engineers to societal needs and values
- The challenge to design multi-actor engagement activities taking into account differences in culture, and communication differences as well as gender
- The policy and organisational challenge to practically realise RRI conditions in nanotechnology research and innovation

(DoA, p. 34)

The three GoNano white papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnology. Each paper addresses the question of ‘conditions for Responsible Research and Innovation (RRI)’ in nanotechnology research and innovation from a different angle.²

As the GoNano project unfolded, the bottom-up process of developing and re-shaping the GoNano white papers and their topics has accompanied the GoNano project throughout the second half of the project. In thorough internal discussions, the topics have been re-shaped to better highlight the GoNano experiences and findings while at the same time pay justice to the original direction of the GoNano project.

The writing process was taken on by individual partners according to their respective expertise, while undergoing extensive feedback loops by the whole consortium before meeting final editing for better harmonization between the papers for better accessibility and readability. In the end, the final topics of the white papers are:

- Responsiveness in practice: aligning nanotechnology research and innovation with societal needs
- Co-creation in practice: enabling multistakeholder collaboration in nanotechnology research and innovation
- The importance of gender and diversity in nanotechnology Research and Innovation

The target groups of the white papers differ as the papers respectively highlight specific aspects of - or brought forward by - co-creation of interest to different actor groups:

² For more information on the RRI framework by the EC please see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>) (30-06-2020). For the aspect of responsiveness please see GoNano white paper 1.

- White paper 1 explores the opportunities and drawbacks of using co-creation as a tool to enhance the responsiveness of nanotechnology research and innovation to societal needs and values. The white paper highlights the findings from the GoNano co-creation process and suggests five rules of thumb for prospective co-creation practitioners. It is mainly targeted at researchers, engineers and other stakeholders involved in research and innovation.
- White paper 2 provides insights on *how to implement co-creation*, considering research as well as the innovation ecosystem. It addresses industrial and business partners, research institutions, and policy makers involved in research and innovation.
- White paper 3 provides guidance on how to realise co-creation in the light of a *gender and diversity perspective* in order to better integrate these perspectives into nano-related research and innovation. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

The first versions of the white papers were finalized in the end of March 2020.

1.2.1. PUBLIC ONLINE CONSULTATION

In the light of the overall aim of GoNano to open up research and innovation to a wider audience and to actively promote co-creation between different stakeholder groups, the GoNano white papers were put online in order to provide a broader audience to comment and give feedback (see Figure 1 for the GoNano website for the public consultation).

The three white papers were put on the GoNano website for a six weeks public consultation phase in April/May 2020.



Figure 1: Screenshot of the GoNano public consultation website inviting people to provide their feedback



To facilitate a transparent feedback process, the decision was made to use a feedback template (Annex 2). The template was intended to be sent to the consortium by e-mail; however, of course, open comments that were received were integrated as well. The received feedback was collected and published on the website as separate document (Annex 3) for public information.

The invitation to contribute to the white papers was widely distributed by the whole GoNano consortium. Messages for LinkedIn and Twitter, as well as informative e-mails were prepared and shared with partners to distribute via their respective networks. Accordingly, invitations were put on the GoNano website, partners' websites where possible, twitter and LinkedIn. Additionally, an invitation e-mail was provided for partners to distribute via GoNano related distribution lists (i.e. GoNano newsletter, participants of the GoNano winter school), as well as partners' individual distribution lists. Also, some effort was made to explicitly invite people who had taken part in the GoNano co-creation process (i.e. stakeholders, policy makers, citizens). For a detailed presentation of the GoNano efforts to raise feedback, please see Annex 4.

Despite this broad invitation effort, there have only been received few feedback templates and mails (four altogether). We see the reasons for this mainly in the outbreak of Corvid-19 from the beginning of March 2020 onwards all over Europe and the deriving shifts in attention.

2. INTRODUCTION TO THE TOPIC: IMPORTANT ASPECTS FOR ALIGNING CO-CREATION WITH NANOTECHNOLOGY RESEARCH

Responsible Research and Innovation (RRI) as pushed by the European Commission (European Commission, 2019) foresees public engagement as one of its core values. Under Horizon2020, the European Commission explicitly bet on co-creation to stress a more active role for non-experts and non-scientists within the development of technology. Citizens and non-experts are invited to actively contribute in a variety of ways; they are expected to provide creative solutions based on out-of-the-box thinking and their perspectives and values regarding the respective technology or challenge.

Experiments to implement co-creation have ranged on various levels – from business to public health, on the level of research agendas as well as specific product consultations.

In this light, GoNano experimented to develop, implement and test a methodology to facilitate co-creation within the nanotechnology realm and across different research domains. As a result, the three white papers provide a synthesis of the findings of the GoNano experiences, sharpened towards three important topics in line with the European Commission's agenda: to make public engagement more active, as well as societal responsible and, more equal and gender considerate.

Hence, the three white papers now follow this distinctive call and (a) focus on a practice-oriented approach (white paper 2), (b) consider societal values in research and innovation (white paper 1), as well as (c) explicitly pay attention to gender and equality issues as this is one of the five main pillars of the RRI concept in general (white paper 3).

In the following section, the three white papers are presented.

- Responsiveness in practice: aligning nanotechnologies with societal needs and values
- Co-creation in practice: enabling multistakeholder collaboration in nanotechnology research and innovation
- The importance of gender and diversity in nanotechnology Research and Innovation

REFERENCES

European Commission (2019). *Implementing RRI in Horizon 2020*. Available from: <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>. (Accessed December 2019).

GoNano D5.5 (forthcoming). Deliverable 5.5: Collection of policy and industry briefs. Brussels: GoNano project.

3. THE GONANO WHITE PAPER SERIES



HIGHLIGHTS FROM THE GONANO WHITE PAPER SERIES

The GoNano white paper series highlights the conclusions derived from the co-creation activities carried out in the project. On the basis of our GoNano experience, we recommend that the following factors should be considered when planning co-creation activities.

A co-creation trajectory involves different groups with varying backgrounds collaborating to reach a suggestion for a new idea, product or process.

Therefore, it is important to...

...know and successfully reach out for the intended target audience

- Identify and assess issues and actors along the whole value chain for scoping as specific as possible
- Address societal challenges or dilemmas to attract the attention of potential participants by using solution or opportunity-oriented framings
- Find ways to improve the conditions to enable responsiveness on the levels of institutions opportunities and organisational culture

As co-creation is not yet mainstreamed and requires a certain openness from participants, make sure that there is...

... willingness to change perspective both as a precondition of co-creation

Foster research and innovation actors' appreciation of the opening up of the research process, and involve perspectives not usually involved in research and innovation, i.e. non-technical understanding of sustainable lifestyle

Challenge the ways in which (the views of) others are anticipated, simplified or ignored in relation to science/scientists, industry/industry representatives and society/citizen-consumers.

In order to facilitate implementation and mainstreaming of co-creation...

... adopt tangible methods for co-creation

- Identify ways to empower actors to express diverse issues (enabling responsiveness)
- Balance actors' involvement: be aware of the trade-offs between specific expertise and societal inclusiveness
- Be cognisant of what it is possible to change within the affected system
- Be aware of potential power differences among the participants: academics, industry representatives, policy makers, civil society representatives and citizens.

This finally allows you to...

...increase your potential gain by co-creation

- Co-creation allows for sharing knowledge across sectors and activities
- Contribute to improve research and innovation strategies and innovation trajectories
- Commonly develop new and original design and product suggestions

3.1. WHITE PAPER 1



Responsiveness in practice: aligning nanotechnologies with societal needs and values

*ENHANCING THE RESPONSIVENESS OF SCIENTISTS AND ENGINEERS TO
SOCIETAL NEEDS AND VALUES -
OPPORTUNITIES AND CHALLENGES FOR CO-CREATION*

| | |
|--------------------------------|--|
| Editors: | Ulrike Bechtold and Daniela Fuchs (OeAW) |
| Compiling author(s): | Clare Shelley-Egan (OSLOMET) Daan Schuurbiers (DPF) |
| Contributing author(s): | Marek Pour and Lenka Hebáková (Technology Centre of the Czech Academy of Sciences, TC CAS), Sikke Jansma and Anne Dijkstra (University of Twente, UT), Craig Richmond (European Office of the Royal Melbourne Institute of Technology, RMIT), Maud Bomert and Hannie van den Bergh (DPF) |

INHALT

| | |
|--|----|
| Executive summary | 4 |
| Foreword | 6 |
| What are the GoNano white papers? | 6 |
| GoNano project and goals | 7 |
| Why responsiveness? | 10 |
| Nanotechnologies and responsiveness | 11 |
| Findings from GoNano: How can co-creation contribute to enhanced responsiveness of researchers and innovators to input from citizens and stakeholders? | 13 |
| Rules of thumb for future co-creation processes | 16 |
| Rule of thumb 1: Nurture opportunities for mutual benefit | 16 |
| Rule of thumb 2: Build 'interactional expertise' between stakeholders | 18 |
| Rule of thumb 3: Acknowledge the transdisciplinary, practice-oriented and iterative nature of co-creation | 19 |
| Rule of thumb 4: Consider the benefits and drawbacks of participation for all participants | 20 |
| Rule of thumb 5: Build trust between participants | 22 |
| References | 23 |

EXECUTIVE SUMMARY

Responsiveness is one of the major objectives of Responsible Research and Innovation (RRI), but practical realisation of the concept remains a challenge. The EU-funded GoNano project understands responsiveness as the capacity of research and innovation actors (researchers, engineers, innovators and producers) to *act* on societal input at a time when technological trajectories are still malleable.

The GoNano project explored the potential of co-creation as a means to enhance the responsiveness of research and innovation. By organising and analysing a series of engagement activities in the Netherlands, the Czech Republic and Spain from October 2018 to November 2019, GoNano elucidated opportunities and challenges of co-creation. The GoNano experience offers insights in the potential value of co-creation: participants valued the general opportunities for mutual learning and networking. However, getting from constructive dialogue to practical action remains a significant bottleneck. The gap between the appreciation of broader issues around research and innovation and the actual integration of those issues in daily research practices and priorities remains significant.

The GoNano experience suggests that co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, ‘translate’ needs and concerns from the social realm to practical options in the technological realm, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

Aligning research and innovation to societal needs and values is not just a matter of deciding what sorts of future applications European citizens and stakeholders *want and need* (which is difficult enough, given widely divergent responses). It is also a matter of *practically realising* the desired change. Due to the relative autonomy of the research and innovation system, calls for responsiveness will need to identify the win-win opportunities where ‘doing good’ and ‘doing well’ coincide.

In order to enhance responsiveness throughout the research process, GoNano has formulated five rules of thumb that emerge from its co-creation experiments:

1. *Nurture opportunities for mutual benefit*
Opportunities for innovation that are both realistic and responsive to societal needs are rare. It takes ample time and devotion, as well as the willingness from all participants to act on them. However, this process involves trade-offs, for instance between enhancing inclusion (democratisation) and adding value in terms of concrete business optimisation.
2. *Build ‘interactional expertise’ between stakeholders*
“Interactional expertise” refers to the ability to converse expertly about a practical skill or expertise, but without being able to practice it, learned through linguistic socialisation among the practitioners (Collins, 2004). The development of a shared language between participants in a co-creation process allows the participants not only to recognise opportunities for building shared value, but also to identify and discuss how to actually realise that value.

3. *Acknowledge the transdisciplinary, practice-oriented and iterative nature of co-creation*
Co-creation is an evolving tool. It is important not only to select the appropriate stage and point in time for engagement, but also to pay attention to the suitability of the format to address specific questions in specific settings with regard to research and innovation activities.
4. *Consider the benefits and drawbacks of participation for all participants*
as co-creation presents opportunities *and* drawbacks. In fact, many 'ordinary', straightforward, technical problems may best be solved by traditional, monodisciplinary teams. It's especially the 'wicked problems' (problems that are impossible to solve and have no single solution because of incomplete, contradictory and changing requirements that are often difficult to recognize) that require collaboration between stakeholders (Rittel and Webber, 1973). Co-creation can be an especially effective tool to tackle these types of problems. Nanotechnology governance is such a wicked problem: the challenges do not reside in the development of the technology itself, but in the required alignment between working practices, responsibilities, knowledge levels, expectations and concerns across widely divergent fields of expertise.
5. *Build trust between participants*
While hard to tackle, building trust between actors involved in engagement procedures to enhance responsiveness is key. It requires openness and a willingness to engage with different perspectives, as well as continuity with regard to engagement.

FOREWORD

WHAT ARE THE GONANO WHITE PAPERS?

The present publication is part of a series of three white papers developed by the GoNano project, covering different aspects of co-creation in research and innovation, with a focus on nanotechnology.

The white papers are intended as a knowledge repository for further GoNano communication activities. As such, they provide relevant background information with condensed GoNano findings. They also form the basis for six policy briefs and two industry briefs outlining the topics with policy and industry relevance.

The three GoNano white papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnologies. Each paper addresses the question of Responsible Research and Innovation (RRI) in nanotechnology research and innovation from a different angle.¹

- White paper 1 explores the opportunities and drawbacks of using co-creation as a tool to enhance the responsiveness of nanotechnology research and innovation to societal needs and values. The white paper highlights the findings from the GoNano co-creation process and suggests five rules of thumb for prospective co-creation practitioners. It is mainly targeted at researchers, engineers and other stakeholders involved in research and innovation.
- White paper 2 provides insights on *how to implement co-creation*, considering research as well as the innovation ecosystem. It addresses industrial and business partners, research institutions, and policy makers involved in research and innovation.
- White paper 3 provides guidance on how to realise co-creation in the light of a *gender and diversity perspective* in order to better integrate these perspectives into nano-related research and innovation. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

¹ For more information on the RRI framework by the EC please see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>) (30-06-2020). For the aspect of responsiveness please see GoNano white paper 1.

GoNANO PROJECT AND GOALS

This white paper explores opportunities and constraints for implementing co-creation in nanotechnology research and innovation practice. It builds on the findings of the GoNano project, which is based on the assumption that several types of knowledge and expertise are needed to support co-creation towards sustainable, acceptable, and desirable applications of nanotechnologies. GoNano explored approaches that could be put into practice in different application areas of nanotechnologies (Health, Food and Energy), combining face-to-face citizen consultations, stakeholder workshops and online consultations (see Figure 1).

There has been growing interest in co-creation in recent years. Generally speaking, co-creation is defined as the practice of collaborative product or service development, as developers and stakeholders work together; or the joint creation of value by the company and the customer; or as allowing the customer to co-construct the service experience to suit their context.²

Co-creation as a method has been applied to research and innovation to achieve very different aims and objectives. Companies have used co-creation to encourage user-led innovation. Their aim is to put the needs of users at the heart of innovation. The Creator Space initiative launched by BASF, for example, aims to foster open innovation within the company.³

Others have used co-creation to enable more democratic decision-making in research and innovation. The EU project Making Sense EU, for example, helped citizens to use academic technologies to make sense of their own environments.⁴

Within the GoNano project, co-creation is applied to strengthen the ability of research and innovation processes to respond and adapt to changing demands. The underlying assumption is that research and innovation will be more socially robust if societal needs and values are considered in the early stages of innovation.

² For further information see GoNano D2.1(2018), for an illustrative example, see experiences of the Fonteer project: https://www.youtube.com/watch?v=VID2EyW5W_k

³ The Creator Space initiative brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes. Originally developed as a one-time initiative to celebrate the 150th anniversary of BASF, the Creator Space now forms an integral part of the company's approach to innovation (in this YouTube video, Elise Kissling, Director of the Creator Space frontend innovation program at BASF, reports on Creator Space: <https://www.youtube.com/watch?v=Y0JuOWO0hB8>).

⁴Using low-cost, open-source technologies, Making Sense EU empowered citizens to discuss methodologies, devise data collection strategies for measuring air pollution, water quality or sound pollution, and interpret the results. It's a win-win project: scientists can use the datasets for their research, and citizens acquire tools to understand their environment and take appropriate action. In this YouTube video Frank Kresin, Managing Director of the Design Lab at the University of Twente, highlights Making Sense EU: <https://www.youtube.com/watch?v=au3uVptWJbU>.

GoNano defines co-creation as “activities [that] enable productive collaborations between researchers and societal stakeholders over longer timeframes, focusing on specific nanotechnology research lines, leading to tangible outcomes such as a new research avenue, proposal, product or prototype”.⁵ (GoNano D2.1, 2018)

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims to anticipate contributions that can serve to make research and innovation more socially relevant.

To do so, co-creation approaches require new forms of collaboration that extend across different disciplines and sectors. (Figure 1)



Figure 1: GoNano co-creation process

THE PROCESS IN DETAIL

GoNano has established an iterative and interactive process through which societal considerations in the area of nanotechnologies⁶ can be integrated into research and innovation. In a series of citizen workshops, citizens expressed their wishes and concerns with respect to each of the application areas. In a series of stakeholder workshops, stakeholders subsequently explored ways to take these wishes and concerns into account in nanotechnology research and innovation.

⁵ For further information, see this earlier report on the co-creation methodology for GoNano: D2.1(2018)

⁶ See GoNano D1.1(2018) and GoNano D2.1(2018) for knowledge base and the methodology developed in earlier stages of the project.

At the start of the iterative and interactive process, the three pilot partners (the University of Twente in the Netherlands, the Technology Centre of the Czech Academy of Sciences in the Czech Republic, and the European Office of the Royal Melbourne Institute of Technology in Spain) organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018.⁷ The aim of the first round of stakeholder workshops was to come up with concrete responsive design suggestions that could be fed back into ongoing research and innovation activities, building on the outcomes of the citizen workshops. The design suggestions were to feed into a next round of citizen consultations, which would again feed into a second round of stakeholder workshops serving to evaluate the uptake of the responsive design suggestions of the previous round. The primary aim was to identify product suggestions which are better aligned with societal needs and values. Taken together, these iterative tasks explore the potential of co-creation in integrating societal values in research and innovation and provide more insight into the more actively-oriented responsiveness of business and industry.

FINDINGS

GoNano elucidated opportunities and challenges of co-creation. The GoNano experience offers insights in the potential value of co-creation: participants valued the general opportunities for mutual learning and networking. However, getting from constructive dialogue to practical action remains a significant bottleneck. The gap between the appreciation of broader issues around research and innovation and the actual integration of those issues in daily research practices and priorities remains significant.

The GoNano experience suggests that co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, 'translate' needs and concerns from the social realm to practical options in the technological realm, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

Aligning research and innovation to societal needs and values is not just a matter of deciding what sorts of future applications European citizens and stakeholders *want and need* (which is difficult enough, given widely divergent responses). It is also a matter of *practically realising* the desired change. Due to the relative autonomy of the research and innovation system, calls for responsiveness will need to identify the win-win opportunities where 'doing good' and 'doing well' coincide.

For further information on the individual steps (citizen workshop, first stakeholder workshop, online consultation, second stakeholder workshop) please see GoNano D4.4, 2020.

⁷ See the briefing report for further information on the outcomes of the citizen workshops (GoNano D3.2, 2019).

WHY RESPONSIVENESS?

Better alignment of research processes and outcomes with the expectations, needs, and values of society continues to grow in importance in the European research and innovation policy context. But what does all this mean in practice?

- How does a research and innovation system become more responsive to societal needs and values?
- Who and what should it respond to?
- What changes to research practices does increased responsiveness require/presuppose?

The answers to these questions differ depending on one's interpretation of the term 'responsiveness'. Following the European Commission's interpretation, the call for responsiveness can be understood as referring to an umbrella term encompassing the movement towards alignment of research and innovation with societal needs and values. Responsiveness can be understood as including technology assessment, research agenda-setting, etc. – all of which lead to alignment in the broad sense. This opening up of the research and innovation agenda in terms of stakeholder engagement, mutual learning and the co-development of research agendas has manifested itself in numerous approaches, ranging from participatory agenda-setting to public engagement to citizen science.

However, responsiveness can also be interpreted as a more targeted concept with an action orientation, namely as the capacity of research and innovation actors (researchers, engineers, innovators and producers) to act on societal input at a time when technological trajectories are still malleable.

While there has been progress towards enabling responsiveness in the broader sense, e.g. with respect to stakeholder engagement and other mutual learning initiatives, there has thus far been less emphasis on responsiveness in the more action-oriented sense. Making genuine steps from reflection to action is necessary in order to sustain trust in the research and innovation system. Thus, it is important to ensure responsiveness as both a main, continuous aim and as a key outcome that is enabled by reflection throughout the whole development and innovation process.

We zoom in on the active interpretation of responsiveness here. We will consider the opportunities and obstacles that came to light in the findings of the GoNano project, which investigated the conditions for enabling responsiveness in the action-oriented sense. GoNano aims to facilitate responsiveness through co-creation, enabling citizens and professional stakeholders to become responsive to each other's needs and concerns; in other words, co-creation is seen as one possible route to enhancing responsiveness in research and innovation. While the GoNano findings as presented in this paper focus specifically on nanotechnologies, the lessons may also apply to research and innovation more broadly.

Data from the GoNano co-creation initiatives and from the literature will be mobilised in order to identify opportunities and obstacles and propose realistic paths forward for researchers required to demonstrate a responsive approach to their research. On the basis of this analysis, we will present some rules of thumb as action points through which to pursue and engender responsiveness.

NANOTECHNOLOGIES AND RESPONSIVENESS

The drive to work closely with society has been particularly visible in the area of nanotechnologies. The fear of a social backlash against nanotechnology similar to the case of genetically modified crops in Europe has been an important driver here, with the promotion of research and innovation coupled with calls for societal engagement ever since nanotechnology started drawing attention as a field of research and economic development. The landmark UK Royal Society and Royal Academy of Engineering nanotechnology report of 2004 noted: *“As recent debates in the UK and elsewhere demonstrate, developments in science and technology do not take place in a social and ethical vacuum. Widespread discussions of issues such as nuclear energy, agricultural biotechnology and embryonic stem cells illustrate this point only too clearly.[...] Given this backdrop, it seems highly likely that some nanotechnologies will raise significant social and ethical concerns.”* (Royal Society & The Royal Academy of Engineering, 2004, p.51). The European Commission’s Strategy for Nanotechnology of 2004 stated that: “An effective two-way dialogue is indispensable, whereby the general public’s views are taken into account and may be seen to influence decisions concerning Research and Development policy. The public trust and acceptance of nanotechnology will be crucial for its long-term development and allow us to profit from its potential benefits.” In the US, the twenty-first century Nanotechnology Research and Development Act similarly mandated the integration of nanotechnology Research and Development with research on societal, ethical and environmental concerns (Fisher, E., & Mahajan, R. L., 2006).

The challenge as to how to integrate public voices has given rise to a steady stream of European outreach and dialogue activities over the last fifteen years or so. The European Commission’s Nanotechnologies, Advanced Materials, Biotechnology, and Advanced Manufacturing and Processing (NMBP) programme has funded a range of dedicated projects including NANODIALOGUE, NANOTOTOUCH, NANOYOU, TIMEFORNANO and SEEINGNANO. The focus of these projects was mostly on outreach, i.e. education and communication, and less focused on practically integrating societal concerns into research and innovation. More recently, projects like the NANODIODE⁸ project have begun to explore how to strengthen the responsiveness of the research and innovation system.

The question therefore remains how to enable new models of innovation that integrate societal considerations earlier and more effectively in the research and innovation process. Nanotechnology governance, including the associated public engagement landscape, is about finding the right level of public oversight needed to maximise the chances of creating maximum public benefit with acceptable levels of risk. This gives rise to some important questions: When should we actively seek to direct or control – govern – research and innovation, and when should we let the market drive innovation, and who should decide?

Nanotechnology engagement has focused on broader notions of responsiveness – and not so much the ability of innovation actors to act. This has led to calls for responsiveness in the more action-oriented sense. The Re-finding Industry report from the High-Level Strategy Group on Industrial

⁸ For further information see: <http://www.nanodiode.eu/> (25-06-2020).



Technologies calls for more social dialogue and participation in Europe, noting that: *“Civil society has a central role in identifying the main challenges, and must be actively involved in the development of missions and projects. The role of society in the missions and projects is not only in the execution phase, but also in most phases of the public policy cycle. Civil society must also take part in the identification of the problem itself, in setting the agenda for solutions, in the policy making and evaluation.”* (Re-Finding Industry, 2018)

The GoNano project is a recent initiative within that broader legacy. It attempts to enhance responsiveness through co-creation and thus provide a concrete way to integrate societal concerns and values into Research and Development. The following section will present the aims and activities of the project in further detail and will reflect on the preliminary findings of the project activities, noting both opportunities and obstacles.

FINDINGS FROM GoNANO: HOW CAN CO-CREATION CONTRIBUTE TO ENHANCED RESPONSIVENESS OF RESEARCHERS AND INNOVATORS TO INPUT FROM CITIZENS AND STAKEHOLDERS?

The overall GoNano experience has elucidated opportunities and challenges of co-creation as a tool to enhance responsiveness of research and innovation. The findings of the GoNano co-creation process confirm that with some effort and careful preparation, it is possible to demonstrate to stakeholders that it does make sense to look at the broader dimensions of research. Indeed, the GoNano co-creation process has offered insights on the potential value of co-creation. Participants valued the general opportunities for mutual learning and networking. The GoNano co-creation process facilitated engagement between stakeholders in nanotechnologies, including citizens, researchers, engineers, producers, civil society and policy makers. The activities contributed to enhanced trust and mutual understanding between citizens and stakeholders.

For instance, a discussion between producers, policy makers, civil society, researchers and a diabetes patient around the artificial pancreas (a monitoring device for diabetes type 1 patients that continuously measures glucose levels of the patients and adds insulin and glucagon when needed) in the first stakeholder workshop on health at the University of Twente led to data management considerations that may be relevant for future data sharing agreements between the producer and users of the device. And the discussions around the Harvestore project in the second stakeholder workshop on energy in Barcelona suggested how societal considerations can be productively integrated in the development of the wireless sensor nodes. These examples suggest that 'exposure' to use considerations further down the line can attune research design to future use contexts.

The outcomes of the overall co-creation process demonstrate how bringing stakeholders with different backgrounds together may lead to relevant discussions and insights for research and product development. The relevance of this finding should not be underestimated: the productive integration of societal considerations in research and innovation will to a large extent depend on mutual learning between stakeholders, and on the shared conviction that broader societal perspectives matter. The co-creation process succeeded in addressing this vital precondition.

However, getting from constructive dialogue to practical action is a significant bottleneck. The gap between the appreciation of broader issues around research and innovation and the actual integration of those issues in daily research practices and priorities remains significant.

One of the main challenges concerns the continuity of the process, both in terms of relating the different steps of the co-creation process to each other, and in terms of between the participants of the different events. The suggestions from citizens were often formulated at a high level of abstraction: for instance, citizens emphasized the importance of values like sustainability, respect for nature and transparency as design considerations. While the participants of the stakeholder workshop acknowledged the importance of these social needs and values, it sometimes proved difficult to derive concrete design recommendations from these high-level considerations.

The findings also suggest that there is a trade-off between inclusiveness and specificity: the decision to treat all stakeholder perspectives on an equal footing for reasons of inclusiveness may come at the cost of a clear action perspective. Conversely, the choice of one particular action perspective to enable specificity is – by definition – partial and exclusive. In the first workshop on diabetes, the focus was on providing suggestions for products developed by the businesses present at the workshop. This discussion was less relevant for some of the researchers present because they were working on research that was at an early Technology Readiness Level (TRL) and so could not be mobilised for product development.

Another trade-off that played a role throughout the design and implementation of the GoNano co-creation process concerned the simultaneous occurrence of two rationales for co-creation. The first rationale considers co-creation as a tool to ‘open up’ research trajectories, inviting multiple stakeholders who would normally not be included in research decision making, and exploring how their views might be more productively integrated in research and innovation trajectories. This rationale has its roots in movements for ‘democratization’ of science.

As such, calls for responsiveness challenge the roles and responsibilities of researchers and redefine the boundary between science and society. In a sense, RRI – and the responsiveness that it purports to advance – can be viewed as a social innovation that is ‘gradually being articulated’. (Rip, 2014)

The second rationale considers co-creation as a means to ‘add value’ to ongoing research trajectories, by inviting feedback from specific stakeholders (prospective users for example) on particular research decisions, and seeing how this feedback might improve the research outcome (by making it more efficient, cheaper, or more acceptable, for instance). While this rationale is borne from the same origins as the democratisation movement, it argues that attempts at democratisation of research and innovation have often had merely tangential effects on the governance of research. Instead, this rationale explores the possibility and utility of ‘governance from within’. (Fisher et al., 2006). Acknowledging the dominant position of technology enactors, it looks at changes in research practice that may be more modest, but can be implemented in concrete decision-making processes. On this view, ‘alignment with societal needs and values’ is interpreted more narrowly: it might include incremental changes in product design to attune the product better to consumer needs. On this approach, some idealism is forfeited for the sake of effectiveness.

To be sure, both rationales are equally valid, and both have played a role in the design of the GoNano project. The workshop outcomes suggest opportunities for both rationales as well. For instance, the consideration of the wishes, needs and messages from citizens during the first stakeholder workshop demonstrate how research trajectories can be ‘opened up’ to societal considerations. And the discussions on autonomous wireless sensor nodes for the future Internet of Things which took place during the second stakeholder workshop on energy in Spain suggests how societal considerations can add value to the development of wireless sensor nodes. However, the GoNano experience suggests that perhaps it is too much to expect both objectives to be addressed *simultaneously*. As D4.2, 2020 also noted, the desire to ‘add value’ to concrete research lines may come at the cost of ‘opening up’ research and innovation, and vice versa.

The GoNano experience suggests that co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, ‘translate’ needs and concerns from the social realm to practical options in the technological realm, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

This suggests that enhancing responsiveness will depend on the function assigned to the opportunities of engagement, e.g. out of the box thinking, as well as re-orienting and potentially challenging aspects previously not considered by actors in research and innovation.

Pilot Health

During the nanotechnology and health stakeholder workshop in Enschede (NL), one of the entrepreneurs observed that the workshop was a ‘reality-check’ of whether they were going in the right direction with their data management plan for artificial pancreas. The developer of the artificial pancreas mentioned that the co-creation workshop gave the team the possibility to explore the societal context in which their product would be implemented.

Example from GoNano

Nevertheless, integration may not go as smoothly as intended even when there is a willingness to consider the suggestions that have been made. During the workshops in The Netherlands and Spain, researchers and developers were motivated to look into the concerns raised by citizens or other researchers regarding data protection. However, concrete actions resulting from these good intentions will only be visible after the co-creation process when the research and/or innovation path will be developed further. That said, being responsive to societal needs also depends on emergence of opportunity, coupled with actors’ ability to recognise and act on an emerging opportunity. This suggests that specific systemic conditions limit (or enhance) opportunities for responsiveness, e.g. whether or not to allow for considering wider societal values while the current system is running.

In the following section, these findings will be synthesised in the form of rules of thumb designed to serve as guidance in establishing and facilitating co-creation exercises.

RULES OF THUMB FOR FUTURE CO-CREATION PROCESSES

The following rules of thumb have been derived from the GoNano findings. They may offer some support to those who are interested in co-creation and its role in relation to RRI.

RULE OF THUMB 1: NURTURE OPPORTUNITIES FOR MUTUAL BENEFIT

WHY

The GoNano co-creation workshops suggest that enhancing the ability of research and innovation actors to act on societal input when technological trajectories are still malleable can present significant – and often overlooked - opportunities to align research and innovation with societal needs and values. However, this comes at a price. Responsiveness is at odds with inclusiveness: enabling research and innovation actors to revise research decisions due to societal considerations is necessarily exclusive.

Opportunities for innovation that are both realistic and responsive to societal needs are rare. It takes ample time and devotion, as well as the willingness from all participants to act on them. However, this process involves trade-offs, for instance between enhancing inclusion (democratisation) and adding value in terms of concrete business optimisation.

How

Our experience from previous projects (NanoDiode, RRI-Practice, and others) and the findings of the academic literature (Fisher and Rip, 2013; Owen et al., 2012; Stilgoe et al., 2012) show that a system's ability to respond and adapt to changing conditions depends on several factors. A key factor for change is the emergence of opportunity, coupled with actors' ability to recognise and act on an emerging opportunity. Especially aligning research and innovation to societal needs and values is not just a matter of deciding what sorts of future applications European citizens and stakeholders want and need (which is difficult enough, given widely divergent responses). It is also a matter of practically realising the desired change.

Another important overall conclusion is that the implementation of a co-creation process that identifies and realises concrete steps towards more socially robust research and innovation requires considerable resources. Co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, 'translate' needs and concerns from the social realm to practical options in the technological realm in real time, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

The GoNano pilots involved multiple stakeholders with the potential to act as change agents in the nanotechnology research and innovation system. They included nanotechnology researchers, industry and innovation network representatives, civil society organisation representatives, citizens and policy makers. Where one stakeholder group sees a challenge, another may see an opportunity; however, simply throwing these diverse groups together does not guarantee a positive outcome – much work must be done in advance to ensure smooth interactions and support the stakeholders' abilities to recognise the opportunities provided through collaborative work modes such as interdisciplinary work and cross-sectoral

approaches. By designing the GoNano co-creation process to include multiple steps with structured and unstructured interactions between stakeholders, the potential for identifying opportunities in nanotechnology research increased (also see GoNano Toolkit⁹). And by including the same stakeholders across the different steps of the co-creation process the prospects of forming the stronger ties needed to act upon these opportunities were also improved.

⁹ <http://gonano-project.eu/toolkit-for-researchers-and-engineers> (16-06-2020)

RULE OF THUMB 2: BUILD 'INTERACTIONAL EXPERTISE' BETWEEN STAKEHOLDERS

WHY

“Interactional expertise” refers to the ability to converse expertly about a practical skill or expertise, but without being able to practice it, learned through linguistic socialisation among the practitioners (Collins, 2004). The development of a shared language between participants in a co-creation process allows the participants not only to recognise opportunities for building shared value, but also to identify and discuss how to realise that value.

How

The purpose of the co-creation event prescribes the actors that should be involved and the ways in which they contribute. When the purpose of the co-creation event leans more towards opening-up research and innovation, the aim is to have a creative *brainstorm session* about possible future applications of nanotechnology. Brainstorming benefits from diversity and equality of the contributors. The more diverse the composition of the group and the wilder the ideas, the more productive the brainstorm session will have been. A shared language allows each participant to meaningfully discuss the ‘value’ of their contribution with the other participants. The ‘symmetry of ignorance’ is a key principle here: this means that we are all expert in some fields, but laypersons in most others.

In other cases, when aiming to add value to ongoing research trajectories for example, detailed understanding of the research choices that are available (hence of the research at hand) is necessary. This means that only those who, at the very least, have interactional expertise can meaningfully participate in these collaborations. In this example, only certain considerations can be operationalised, i.e. those that can be operationalised at the level of research decisions. In other words, certain things need to be taken for granted (e.g. it does not make sense at this level to conclude that the type of research at hand should not be carried out at all. While this could be a legitimate conclusion, it moves the debate into the policy arena).

RULE OF THUMB 3: ACKNOWLEDGE THE TRANSDISCIPLINARY, PRACTICE-ORIENTED AND ITERATIVE NATURE OF CO-CREATION

WHY

Co-creation is an evolving tool. It is important not only to select the appropriate stage and point in time for engagement, but also to pay attention to the suitability of the format to address specific questions in specific settings with regard to research and innovation activities.

How

By understanding the potential and limitations of distinct forms of engagement; targeting them to the appropriate stage in the innovation process; and adjusting the nature of the engagement measures to the specific actors, while being aware of the opportunities and challenges of each form of engagement.

GoNano demonstrated that the purpose of the co-creation event prescribes the co-creation approach, goal and tools. For instance, citizen and multi-actor consultations could help to determine the sorts of research that we – as a society – do or do not want to pursue, and the ways in which we do or do not want nanotechnology to shape our society. GoNano used future scenarios of future nanotechnology application to help visualise future products of nanotechnology, and raise questions on acceptability, sustainability and desirability.

More focused and in-depth co-creation approaches can be used to integrate specific societal considerations into concrete research trajectories. In order to achieve such in-depth approaches, GoNano structured the workshops around four interrelated co-creation sessions: exploration, ideation, prototyping and reflection. Each step had its own purpose (such as getting to know each other needs and wishes in the exploration phase or having a more focussed discussion and trying to generate a concrete suggestion for research lines or product innovations). It is also important to consider the different roles of various stakeholders at every step of the value chain. Creating a stakeholder map can contribute to the *ex ante* definition of the kind of interaction required from the specific actor group (e.g. listen, decide, provide knowledge, and so on) and at which step of the value chain this interaction should take place (see white paper 2).

RULE OF THUMB 4: CONSIDER THE BENEFITS AND DRAWBACKS OF PARTICIPATION FOR ALL PARTICIPANTS

WHY

Co-creation presents opportunities *and* drawbacks. In fact, many 'ordinary', straightforward, technical problems may best be solved by traditional, monodisciplinary teams. It's especially the 'wicked problems' (problems that are impossible to solve and have no single solution because of incomplete, contradictory and changing requirements that are often difficult to recognize) that require collaboration between stakeholders (Rittel and Webber, 1973). Co-creation can be an especially effective tool to tackle these types of problems. Nanotechnology governance is such a wicked problem: the challenges do not reside in the development of the technology itself, but in the required alignment between working practices, responsibilities, knowledge levels, expectations and concerns across widely divergent fields of expertise.

The question of 'What's in it for me?' is a question that each participant will ask herself. Stakeholders must see this added value in the interaction in relation to their individual goals and objectives themselves. Researchers, for example, do not see stakeholder involvement as core business. It will only become core business for them if enactors see the added value of these interactions in relation to their own goals and objectives. This requires compelling examples that demonstrate how the research improved or how resistance was overcome. The FoTRRIS project¹⁰ found that a positive correlation can be seen between the relevance of cooperation for a particular research field and the willingness of research and innovation actors to engage in collaboration. Thus, drivers for involvement in a co-creation project should be carefully considered. For example, academics may seek to move closer to industrial contexts by improving the industrial relevance of their training programmes and ensuring the societal relevance of their research programmes.

Moreover, close collaboration with non-research actors should not put the research and innovation community's autonomy and independence at risk. If we want to engage researchers, it is our responsibility to demonstrate that it does make sense to look at the broader dimensions: this can be achieved by highlighting that such reflection can help researchers to achieve their own goals (this is first-order learning). In order to achieve this, social sciences and humanities communities need to strengthen their consultancy skills and their ability to understand the context and 'DNA' of the actors involved:

- from product-driven ('Here's my theory, what do you think?') to demand-driven: 'How can I help you?'
- clear and compelling examples, presented in a way that non-experts can understand

¹⁰<http://fotrris-h2020.eu/> (25-06-2020)

How

As co-creation comes in many shapes and sizes, each type of co-creation involves different types of actors, with different expected outputs in different stages of innovation. The *purpose* of the event prescribes the actors that should be involved and the ways in which they contribute. Seeking a shared goal that drives collaboration between stakeholders is key: all participants need to be intrinsically motivated in order to get involved and remain involved. This might involve mobilisation around a specific problem that requires a need for consensus, e.g. how can we move forward in tackling this problem? Going back to the example in the *why* section above, researchers and developers will need to know why, to what end, and when they need input from stakeholders. Defining what is at stake is crucial. In other words, it is necessary to have a clear problem diagnosis, e.g. exploring norms and values related to the technology at stake, the potential contributions of citizens to the research process and, especially in the case of nanotechnology, the degree of urgency and openness with regard to research activities. In short, expectation management on different levels is key.

Focussing on researchers specifically, in order to motivate scientists to participate in and engage with co-creation exercises, it may be helpful to find individuals within the scientific community who want to do something that may not be immediately useful to their own research, i.e. those scientists who are not continuously concerned about 'What's in it?' for them. Ideally, co-creation projects like GoNano would work with scientists and researchers who are interested in collaboration whether it serves their own purposes or not and who find during the collaboration that it is actually relevant to their work.

RULE OF THUMB 5: BUILD TRUST BETWEEN PARTICIPANTS

WHY

Close collaboration as required by co-creation is far from being a mainstream procedure; this means it is crucial to establish trust in both people and organisations as well as in the co-creation process itself. People have to be open and willing to see the 'win-win' of co-creation and to trust each other and their respective roles in the process. A partnership has to be allowed to develop; this might be related to opening up research and innovation (claim to more and broader inclusion) or adding value (claim to improve specific products). Co-creation work will take on varying degrees of importance and meaning according to the type of stakeholder involved.

How

Establish a culture of thorough argumentation: whoever participates and shares their knowledge (regardless of expert knowledge or lay knowledge) needs to know that they are being listened to, that they have a say, and how their input will be further processed (communication and transparency). Since co-creation events often involves collaboration between individuals with very different backgrounds. To build trust and work together effectively, participants have to learn where the others are coming from and what they would like to achieve. By building a shared language, it allows each participant to meaningfully discuss the 'value' of their contribution with the other participants. Building shared understanding between participants also implies that clear ground rules for discussion should be in place: everyone should be allowed to speak; participants should actively listen to what the others have to say; they treat each other as equals; they explore what new and crazy ideas might contribute to the overall aim, rather than simply dismissing them; differences in opinion are valued, not suppressed.

This, however, should not stop at the level of individual co-creation or engagement processes, but extend to the policy arena: Why and how are inputs, thoughts and reflections there included or excluded? Keep participants informed about the outcomes of the project and build a community of interested people. This also makes it easier to disseminate results after the project and to ensure that other people get to know about the project.

REFERENCES

- Collins, H. (2004). Interactional expertise as a third kind of knowledge. *Phenomenology and the Cognitive Sciences* 3, 125–143. <https://doi.org/10.1023/B:PHEN.0000040824.89221.1a>
- European Commission. (2007). Work programme 2007, Capacities, Part 5, Science in Society. C(2007)563.
- European Commission. (2019) Implementing RRI in Horizon 2020. Available from: <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>. (Accessed December 2019).
- Fisher, E., Mahajan, R.L. and Mitcham, C. (2006) Midstream Modulation of Technology: Governance From Within. *Bulletin of Science Technology & Society* 26(6):485-496. 10.1177/0270467606295402.
- Fisher, E., and Mahajan, R. L. (2006). Contradictory intent? US federal legislation on integrating societal concerns into nanotechnology research and development. *Science and Public Policy*. 33(1):5–16
- Fisher, E., and Rip, A. (2013). Responsible innovation: Multi-level dynamics and soft intervention practices. In R. Owen, J. Bessant, & M. Heintz (Eds.), *Responsible innovation: Managing the responsible emergence of science and innovation in society* (pp. 51–74). London: Wiley.
- GoNano D1.1 (2018) Deliverable 1.1: Building on the state-of-the-art: ex-post evaluation on mutual learning. Brussels: GoNano project.
- GoNano D2.1. (2018). Deliverable 2.1: Method and manuals for the pilot studies: towards a GoNano co-creation approach. Brussels: GoNano project.
- GoNano D3.2. (2019). Deliverable 3.2: Citizen needs and values in relation to nanotechnology in food, energy and health: A report from citizen workshops in the Czech Republic, Spain and the Netherlands. Brussels: GoNano project.
- GoNano D4.2. (2019). Deliverable 4.2: Working paper on the designs and outcomes of workshop round 1. Brussels: GoNano project.
- GoNano D4.4 (2020) Deliverable 4.4: Final report on the insights and lessons from the engagement activities. Brussels: GoNano project.
- Owen, R., Macnaghten, P. and Stilgoe, J. (2012). Responsible research and innovation: From science in society, to science for society, with society. *Science and Public Policy*, 39, 751–760.
- Re-Finding Industry. Report from the High-Level Strategy Group on Industrial Technologies. European Commission, 2018.
- Rip, A. (2014). The past and future of RRI. *Life Sciences, Society and Policy*, 10(17), 1–15.



Rittel, H.W. J. & M.M. Webber. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences* 4: 155–169.

Royal Society & The Royal Academy of Engineering. (2004). *Nanoscience and nanotechnologies: Opportunities and uncertainties*. London: Royal Society.

Schuurbiers, D. and Fisher, E., 2009. Lab-scale intervention. *EMBO reports*, 10(5), pp.424-427.

Stilgoe, J., Owen, R., and Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, 42(9), 1568-1580

3.2. WHITE PAPER 2



Co-creation in practice: enabling multi-stakeholder collaboration in nanotechnology research and innovation

*POLICY AND ORGANISATIONAL OPPORTUNITIES AND CHALLENGES FOR
PRACTICALLY REALISING RRI CONDITIONS
IN NANOTECHNOLOGY RESEARCH AND INNOVATION*



| | |
|--------------------------------|--|
| Editors: | Ulrike Bechtold and Daniela Fuchs (OeAW) |
| Compiling author(s): | Daniela Pimponi, Andrea Porcari, and Elvio Mantovani (Italian Association for Industrial Research), David Azoulay (Centre for International Environmental Law) |
| Contributing author(s): | Marek Pour and Lenka Hebáková (Technology Centre of the Czech Academy of Sciences, TC CAS), Sikke Jansma and Anne Dijkstra (University of Twente, UT), Craig Richmond (European Office of the Royal Melbourne Institute of Technology, RMIT), Maud Bomert, Hannie van den Bergh and Daan Schuubiers (DPF), Harald Throne - Holst, Clare Shelley - Egan (OSLOMET) |

INHALT

| | |
|--|----|
| Executive summary | 4 |
| Foreword | 6 |
| What are the GoNano white papers? | 6 |
| GoNano project and goals | 7 |
| Finding a place for co-creation in research and innovation processes | 10 |
| Essential elements for co-creation uptake in research and innovation..... | 13 |
| as identified by GoNano experience..... | 13 |
| Current conditions in nanotechnology development | 15 |
| ... that co-creation approaches could help to address..... | 15 |
| Specific challenges for co-creation..... | 17 |
| ...with regard to nanotechnologies | 17 |
| ... with regard to co-creation..... | 17 |
| Recommendations for actions to establish co-creation | 19 |
| Recommendation 1: identify needs and entry points for co-creation..... | 20 |
| Recommendation 2: mapping the innovation context | 22 |
| Recommendation 3: showcase benefits of co-creation..... | 24 |
| Recommendation 4: implement a structured methodology for co-creation | 26 |
| Recommendation 5: Balance co-creation and research and innovation objectives..... | 28 |
| Recommendation 6: ensure understanding between perspectives of researchers, stakeholders and society | 30 |
| Recommendation 7: create a culture of co-creation | 31 |
| References..... | 33 |

EXECUTIVE SUMMARY

Nanotechnologies and nanomaterials have served as a test field for governance approaches to emerging technologies for over 15 years. Induced and fuelled by both anticipation of new risk profiles and public concern, approaches such as Responsible Research and Innovation (RRI), aim at redistributing responsibility among *all relevant* actors to align their input closer to innovation processes. Here, co-creation appears as one potential approach to the inclusion of a broader public in state-of-the-art research and innovation activities.

Co-creating nano-related products, as pursued in GoNano, may therefore be considered as a bridging activity between the societal realm, research and innovation actors, and policy. Established practices and processes for research and innovation are routinised within the innovation system, which means that from the point of view of industrial stakeholders and policy makers or regulators, integrating input from the broader society may appear challenging.

This GoNano white paper identifies opportunities and challenges for co-creation in order to provide interested parties (e.g. industrial stakeholders and research organisations) with a hands-on guidance of what to consider when thinking about implementing co-creation.

The concept of research and innovation value chain is used in the report to illustrate pre-conditions, practices and benefits to implement co-creation in research and innovation.

In this context, product suggestions emerging from the co-creation process represent condensation points of discussion, rooted in actual challenges for innovation as identified by different actors. The resulting project ideas and objects may mobilise different actor groups so that they can concretely, and together, define directions of and limitations to research and innovation.

The seven GoNano recommendations for mainstreaming and implementing a co-creation process are:

1. *Identify needs and entry points for co-creation*
Be clear about what your co-creation experience should be about (topic) and what you are doing it for (objective).
2. *Map the innovation context*
Assess the state-of-the-art of research, the stakeholders and their interests, and contextual factors (e.g. regulations) that need to be considered in the research and innovation area where co-creation takes place.
3. *Showcase the benefits of co-creation*
Identify good practice examples of how stakeholders have benefited from co-creation. For example, better and more accepted products, networking opportunities, improved market shares, or more socially robust decision-making.
4. *Implement a structured methodology*
Reflect on your own requirements for co-creation beforehand, take into account the specificity of your own research landscape and organisation culture, and the variety of engagement practices available. Selecting a structured and suitable co-creation methodology to reach your objectives will make it easier. And then: do it!

5. *Balance co-creation and research and innovation objectives in scheduling*

Co-creation involves two different objectives: the first one aiming to include as much ideas, values, and concerns as possible to inspire new research trajectories; the second one to distil stakeholder inputs into concrete suggestions for product development. Both approaches are needed, but it is crucial to find the right balance between them and align their outcomes to the different stages of the research and innovation process.

6. *Ensure understanding between perspectives of researchers, stakeholders and society*

Finding consensus on broad societal goals is usually rather easy – no one is against responsible innovation. However, the meanings of such terms may differ between actor groups, especially when their worlds hardly meet – as may be the case for a wider public and researchers or industries. Successful co-creation has to make sure to establish a respectful and trustful relationship between different actor groups as well as shared understanding and language.

7. *Restructure the environment: Create a culture of co-creation*

These tall orders as outlined above can hardly be carried out by researchers on their individual shoulders: collaboration and co-creation need to become mainstream practices in research and innovation and this implies overcoming a lack of incentive structures for researchers, confidentiality or IP limitations and other obstacles. So, if a change in culture is required, this needs fundamental rethinking of research practices, research funding, and incentive structures.

FOREWORD

WHAT ARE THE GONANO WHITE PAPERS?

The present publication is part of a series of three white papers developed by the GoNano project, covering different aspects of co-creation in research and innovation, with a focus on nanotechnology.

The white papers are intended as a knowledge repository for further GoNano communication activities. As such, they provide relevant background information with condensed GoNano findings. They also form the basis for six policy briefs and two industry briefs outlining the topics with policy and industry relevance.

The three GoNano white papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnologies. Each paper addresses the question of Responsible Research and Innovation (RRI) in nanotechnology research and innovation from a different angle.¹

- White paper 1 explores the opportunities and drawbacks of using co-creation as a tool to enhance the responsiveness of nanotechnology research and innovation to societal needs and values. The white paper highlights the findings from the GoNano co-creation process and suggests five rules of thumb for prospective co-creation practitioners. It is mainly targeted at researchers, engineers and other stakeholders involved in research and innovation.
- White paper 2 provides insights on *how to implement co-creation*, considering research as well as the innovation ecosystem. It addresses industrial and business partners, research institutions, and policy makers involved in research and innovation.
- White paper 3 provides guidance on how to realise co-creation in the light of a *gender and diversity perspective* in order to better integrate these perspectives into nano-related research and innovation. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

¹ For more information on the RRI framework by the EC please see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>) (30-06-2020). For the aspect of responsiveness please see GoNano white paper 1.

GoNANO PROJECT AND GOALS

This white paper explores opportunities and constraints for implementing co-creation in nanotechnology research and innovation practice. It builds on the findings of the GoNano project, which is based on the assumption that several types of knowledge and expertise are needed to support co-creation towards sustainable, acceptable, and desirable applications of nanotechnologies. GoNano explored approaches that could be put into practice in different application areas of nanotechnologies (Health, Food and Energy), combining face-to-face citizen consultations, stakeholder workshops and online consultations (see Figure 1).

There has been growing interest in co-creation in recent years. Generally speaking, co-creation is defined as the practice of collaborative product or service development, as developers and stakeholders work together; or the joint creation of value by the company and the customer; or as allowing the customer to co-construct the service experience to suit their context.²

Co-creation as a method has been applied to research and innovation to achieve very different aims and objectives. Companies have used co-creation to encourage user-led innovation. Their aim is to put the needs of users at the heart of innovation. The Creator Space initiative launched by BASF, for example, aims to foster open innovation within the company.³

Others have used co-creation to enable more democratic decision-making in research and innovation. The EU project Making Sense EU, for example, helped citizens to use academic technologies to make sense of their own environments.⁴

Within the GoNano project, co-creation is applied to strengthen the ability of research and innovation processes to respond and adapt to changing demands. The underlying assumption is that research and innovation will be more socially robust if societal needs and values are considered in the early stages of innovation.

² For further information see GoNano D2.1(2018) or, for an illustrative example, see experiences of the Fonteer project: https://www.youtube.com/watch?v=VID2EyW5W_k (30-06-2020).

³ The Creator Space initiative brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes. Originally developed as a one-time initiative to celebrate the 150th anniversary of BASF, the Creator Space now forms an integral part of the company's approach to innovation (in this YouTube video, Elise Kissling, Director of the Creator Space frontend innovation program at BASF, reports on Creator Space: <https://www.youtube.com/watch?v=Y0JuOW00hB8> (30-06-2020).

⁴ Using low-cost, open-source technologies, Making Sense EU empowered citizens to discuss methodologies, devise data collection strategies for measuring air pollution, water quality or sound pollution, and interpret the results. It's a win-win project: scientists can use the datasets for their research, and citizens acquire tools to understand their environment and take appropriate action. In this YouTube video Frank Kresin, Managing Director of the Design Lab at the University of Twente, highlights Making Sense EU: <https://www.youtube.com/watch?v=au3uVptWJbU> (30-06-2020).

GoNano defines co-creation as “activities [that] enable productive collaborations between researchers and societal stakeholders over longer timeframes, focusing on specific nanotechnology research lines, leading to tangible outcomes such as a new research avenue, proposal, product or prototype”.⁵ (GoNano D2.1, 2018)

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims to anticipate contributions that can serve to make research and innovation more socially relevant.

To do so, co-creation approaches require new forms of collaboration that extend across different disciplines and sectors. (Figure 1)

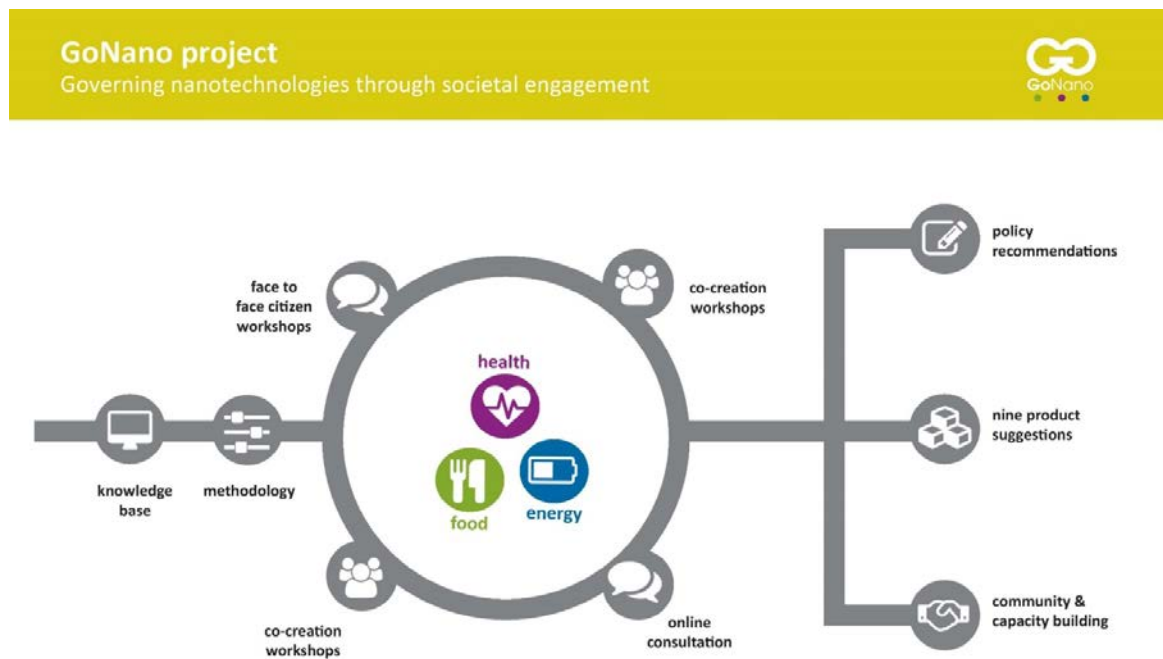


Figure 1: GoNano co-creation process

THE PROCESS IN DETAIL

GoNano has established an iterative and interactive process through which societal considerations in the area of nanotechnologies⁶ can be integrated into research and innovation. In a series of citizen workshops, citizens expressed their wishes and concerns with respect to each of the application areas. In a series of stakeholder workshops, stakeholders subsequently explored ways to take these wishes and concerns into account in nanotechnology research and innovation.

⁵For further information, see this earlier report on the co-creation methodology for GoNano: D2.1(2018)

⁶ See GoNano D1.1(2018) and 2.1(2018) for knowledge base and the methodology developed in earlier stages of the project.

At the start of the iterative and interactive process, the three pilot partners (the University of Twente in the Netherlands, the Technology Centre of the Czech Academy of Sciences in the Czech Republic, and the European Office of the Royal Melbourne Institute of Technology in Spain) organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018.⁷ The aim of the first round of stakeholder workshops was to come up with concrete responsive design suggestions that could be fed back into ongoing research and innovation activities, building on the outcomes of the citizen workshops. The design suggestions were to feed into a next round of citizen consultations, which would again feed into a second round of stakeholder workshops serving to evaluate the uptake of the responsive design suggestions of the previous round. The primary aim was to identify product suggestions which are better aligned with societal needs and values. Taken together, these iterative tasks explore the potential of co-creation in integrating societal values in research and innovation and provide more insight into the more actively-oriented responsiveness of business and industry.

FINDINGS

GoNano elucidated opportunities and challenges of co-creation. The GoNano experience offers insights in the potential value of co-creation: participants valued the general opportunities for mutual learning and networking. However, getting from constructive dialogue to practical action remains a significant bottleneck. The gap between the appreciation of broader issues around research and innovation and the actual integration of those issues in daily research practices and priorities remains significant.

The GoNano experience suggests that co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, 'translate' needs and concerns from the social realm to practical options in the technological realm, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

Aligning research and innovation to societal needs and values is not just a matter of deciding what sorts of future applications European citizens and stakeholders *want and need* (which is difficult enough, given widely divergent responses). It is also a matter of *practically realising* the desired change. Due to the relative autonomy of the research and innovation system, calls for responsiveness will need to identify the win-win opportunities where 'doing good' and 'doing well' coincide.

For further information on the individual steps (citizen workshop, first stakeholder workshop, online consultation, second stakeholder workshop) please see GoNano D4.4, 2020.

⁷ See the briefing report for further information on the outcomes of the citizen workshops. (GoNano D3.2, 2019)

FINDING A PLACE FOR CO-CREATION IN RESEARCH AND INNOVATION PROCESSES

Nanomaterials and nano-based products have experienced a rapid development and a broad diffusion due to a huge range of applications during the last 15 years. Therefore, they provide a good example of what are known as Transformative or Enabling Technologies: technologies requiring a strong knowledge base for their development, together with intensive research and innovation and highly skilled human resources, showing a systemic relevance for all phases of product development, with the capacity to provide pervasive innovation throughout the economy and to enable new paradigms and processes, and which are strongly multidisciplinary and trans-sectoral (DG Research and Innovation, 2018).

These characteristics make the development of Enabling Technologies, such as nanomaterials and nanotechnologies, a useful opportunity to tackle grand challenges and responses to citizens' needs. At the same time, however, the rapid and large amount of disruptive applications they can enable may give rise to new (real or perceived) problems and concerns. Typical examples of this are the safety and health issues associated with the introduction of nanomaterials in products (e.g. cosmetics or food) and the governance of possible risks for the workers at manufacturing sites producing or employing nanomaterials.

Including stakeholder engagement in the research and innovation process could be a useful way to exploit the opportunities provided by new technologies while taking into account societal needs and concerns. GoNano experimented with the co-creation methodology as a way to incorporate stakeholder engagement into research and innovation processes.

Enabling technologies are characterised by a high degree of uncertainty at different levels, including scientific, technical, legal, social and market and consumer acceptability aspects. Investing in research and innovation requires a huge amount of effort, and by definition its outcomes are uncertain; this implies a degree of risk. Furthermore, effecting change in the development of a new product or solution becomes increasingly more expensive when intervening further up the Research and Development value chain, as is known from the Collingridge dilemma (Genus and Stirling, 2017; Collingridge, 1980). Looking at RRI all along the research and innovation value chain is thus fundamental, and co-creation and stakeholder engagement could play a central role to this end.

However, the challenge of co-creation is significant. All participants come to the table with their own assumptions and standard repertoires, which can compromise the willingness and thus the opportunities for mutual learning and co-creation. Such approaches provide the opportunity to broaden one's perspective beyond individual opinions by interaction. As a result, they may contribute to overcoming the widespread prejudice which perceives ethics or broader issues as hindrances to innovation processes (even if this is mistaken) (Tuncak, 2013).

As such, RRI and associated calls for responsiveness challenge the roles and responsibilities of researchers and redefines the boundary between science and society. In a sense, RRI - and the responsiveness that it purports to advance - can be viewed as a social innovation that is "gradually being articulated" (Rip, 2014). The social innovation is visible in the call for researchers to extend their roles and responsibilities to consider input from outside the research and innovation ecosystem and to actually act on this input, in order to adapt - and potentially reconsider- the direction and trajectory of the research and innovation process itself.

In order to align innovation with societal values and bring more value to people it is important to adopt a life cycle view, considering the entire research and innovation value chain, from the lab to the market and the end of life of a product (see Figure 2). Alignment to societal values calls for research and innovation processes that are able to look beyond the primary use and market and consider the entire product life cycle (GoNano D5.1, 2018; GoNano D5.2, 2019).



Figure 2: Research and Development value chain

Enabling technologies such as nanotechnologies are expected to have huge impacts on society, but this doesn't necessarily guarantee that the overall impact will be positive, that supposedly disruptive technologies will effectively succeed, or that companies bringing these solutions to the market will effectively reap commercial reward from it: their success will depend on their ability to provide real benefits for all. Including stakeholders' views in the development of technological innovations could be an effective method to increasing their acceptability.

In all phases of the Research and Development process, there could be positive implications to be further exploited or negative ones to be avoided from the societal, sustainability or economical point of view. Co-creation has the potential to foresee many of these implications, or at least identify them in a timely manner. Despite these added values of co-creation to connect and bring into contact multiple stakeholders, GoNano identified structural and economic issues that prevent the creation of productive connections between the stakeholders along the research and innovation value chain and impede the bridging of the gaps in the innovation process. This is a crucial point for policy and funders of research and innovation activities.⁸

This white paper proposes an overall framework to pursue the GoNano vision of co-creation (Figure 1) that identifies three levels of analysis:

- **essential elements for co-creation uptake in research and innovation**, as identified by GoNano experience
- **current conditions, barriers and challenges** in nanotechnology development that co-creation approaches could help to address
- **recommendations** to promote and perform co-creation in the research and innovation process

⁸ Initiatives such as the report from the project Value4Nano (NANO futures, European Technology Integrating and Innovation Platform on Nanotechnology, 2015) and the Re-finding Industry report have recommended the creation of clusters based on a European value chain approach (European Commission - Directorate General for Research and Innovation, 2019). Similar observations have been made by others.

| Objective of co-creation Aligning innovation with societal needs through more participatory and responsive approaches | | |
|--|--|---|
| Elements for co-creation uptake in R&I | Gaps and challenges for co-creation in Nanotech R&I | Recommendations for co-creation in R&I |
| <ul style="list-style-type: none"> • Interact with the Innovation ecosystem • Enable citizen participation • Ensure awareness of participants • Provide feedback to stakeholders • Ensure responsiveness towards public and stakeholders concerns | <p>With regard to Nanotechnologies</p> <ul style="list-style-type: none"> • Safety • Transparency • Acceptability • Trust <p>With regard to co-creation</p> <ul style="list-style-type: none"> • Added value • Methodologies | <ul style="list-style-type: none"> • Identify needs and entry points • Map the innovation context • Showcase benefits • Implement a structured methodology • Balance co-creation and R&I objectives • Ensure understanding between different perspectives • Create a culture for co-creation |

Figure 3: The framework identified in this white paper to align nano-enabled innovation with societal needs through co-creation

ESSENTIAL ELEMENTS FOR CO-CREATION UPTAKE IN RESEARCH AND INNOVATION

.... AS IDENTIFIED BY GONANO EXPERIENCE

Co-creation is a form of collaborative innovation where ideas are shared and improved together (GoNano D2.1, 2018). Essential actions/elements to obtain tangible outcomes from co-creation are:

- *multi-actor engagement*, to gather different perspectives in the Research and Development value chain and get access to the diverse range of skills needed to develop complex solutions based on enabling or disruptive technologies.
- *citizen participation*, in order to reassure citizens that their concerns matter and that their visions are important for the development of solutions.
- the consideration of the whole *innovation ecosystem*, including the stakeholders involved and their roles and relationships.
- instruments to provide *feedback* to the stakeholders involved, so they can appreciate the responsiveness of other stakeholders and the added value of the co-creation process.
- the *awareness* of the participants and their willingness to continue participating during the process.
- the *responsiveness* of innovators to the concerns, positions and perspectives of all other stakeholders.

Even when these essential elements are already present co-creation may be a challenging exercise, as shown by telling examples from the GoNano experience below.

| | |
|--------------|---|
| Pilot Energy | <i>"We knew what we wanted to do but didn't always manage to put it into practice, e.g. stakeholder workshops in Spain were mostly attended by researchers, even though we had done our best to get all stakeholder groups involved."</i> This, however, may also be related to the focus on trying out the method rather than starting from a pre-existing problem or opportunity. (co-creation pilot on energy, Spain) |
| Pilot Food | <i>"It takes quite some time to understand the specific take on the development of nanotechnology in regard to the expertise of the stakeholders and the different aspects and views that these stakeholders bring to the table."</i> (co-creation pilot on food, Czech Republic) |
| Pilot Health | <i>"GoNano partners managed to bring stakeholders from different backgrounds (research, industry, policymaking, CSO and citizens) together at the workshops, as they were interested in meeting other stakeholders or learning more about the co-creation process. However, it was difficult to ensure responsiveness, in the sense that the suggestions made during the workshops were taken up by them. Most of the stakeholders did not feel a sense of problem-ownership."</i> (co-creation pilot on healthcare, the Netherlands) |
| Pilot Food | <i>"Although some steps of the co-creation process at some point seem to bring fewer tangible results than the others, in the end all the steps play similarly important roles in making the process more valuable and useful for the stakeholders, citizens, and researchers behind the methodology."</i> (co-creation pilot on food, Czech Republic) |

Pilot Health

“During the citizen workshop we had a first session about data management: ownership, sharing etc. We had a second loop during the first stakeholder workshop and we continued this topic a third time during the second stakeholder workshop. Then we focused more and more on data and diabetes. This iteration process was very effective.” (co-creation pilot on healthcare, the Netherlands)

“To discuss the topic of data management and diabetes, we not only have to talk with ICT technology people but also with clients/customers, health insurance companies, doctors, and lawyers to ensure that all specific elements are taken into account. Organising a co-creation workshop is complex and time-consuming.” (co-creation pilot on healthcare, the Netherlands)

Pilot Food

“The first stakeholder workshop included a range of stakeholders from different backgrounds. It proved quite difficult to manage the expectations of all these actors. Moreover, it seemed challenging to manifest the added value of the initial input from citizens. A more focused approach and a more sophisticated input, in the form of the results of the online consultation, seemed to be crucial to managing the expectations and achieving more focused results during the second stakeholder workshop.” (co-creation pilot on food, Czech Republic)

CURRENT CONDITIONS IN NANOTECHNOLOGY DEVELOPMENT

... THAT CO-CREATION APPROACHES COULD HELP TO ADDRESS

Based on desk analysis and interviews with stakeholders GoNano identified some of the main challenges of nano-enabled innovation⁹ (GoNano D5.1, 2018; GoNano D5.2, 2019). Table 1 shows a selection of them, that need to be considered when designing and performing co-creation for this technology. The aspects that co-creation processes might help to address are highlighted in italics.

Table 1: Major issues and gaps in nanotechnology development

| Areas | Specific challenges, and potential anchor points for improvement through co-creation processes (<i>marked in italic</i>) |
|---|---|
| Regulatory and safety aspects | <ul style="list-style-type: none"> Standardisation, classification and definitions of nanomaterials Health and environmental impacts <i>Regulatory preparedness: discrepancy in pace between technology development and safety testing/risk assessment of nanomaterials, and resulting gaps in implementation of regulation</i> <i>Lack of social debate on regulatory and safety aspects</i> |
| <i>Ethical, social and environmental aspects</i> | <ul style="list-style-type: none"> <i>Acceptability, risk perception, sociological aspects</i> <i>Equity and justice in access to new technologies</i> <i>Environmental and sustainability aspects</i> |
| Strategic and systemic aspects | <ul style="list-style-type: none"> <i>Structural, cultural and economic issues preventing connection of stakeholders along the research and innovation value chain and impeding the connection from research to market (e.g. how to support SMEs in open innovation processes)</i> <i>Mainstreaming of Responsible Research and Innovation</i> |
| Communication aspects | <ul style="list-style-type: none"> <i>Absent or misleading information on nanotechnology; fear of nanotech; considering cultural differences. How to provide balanced information to citizens on use of nanotechnology</i> Tangibility of nano-debate: Avoidance of negative effects of a single nanomaterial could influence reputation of nanotechnology as a whole <i>Distinction between nanomaterials and nanotechnology in public debate</i> |
| Institutional and policy aspects | <ul style="list-style-type: none"> International harmonisation |
| Scientific and technological aspects | <ul style="list-style-type: none"> Challenges of collecting adequate scientific data for characterisation and safety Sharing of scientific data, including sharing and harmonisation of modelling tools |
| Economic and market aspects | <ul style="list-style-type: none"> Cost-effectiveness of the fabrication and scale-up of nanomaterial-based technologies Affordability of technologies and innovation |

⁹ With reference to the topics included in this section, it is important to underline that three large EU projects (Gov4Nano, Nanorigo and RiskGone) are now exploring a harmonised approach to these aspects with the aim of developing establishing a European Council for the Risk Governance of Nanomaterials (for further information see GoNano D5.2,2019).

Co-creation is not expected to contribute to all these areas, but this provides an idea of the innovation context for nanotechnology and of the different issues that various stakeholders may have to deal with. Co-creation could become a useful methodology to address some of these issues, for example helping to achieve regulatory preparedness by bringing together disparate fields of expertise or developing nanotechnology risk governance approaches by improving collaboration between actors along the value chain (producers, downstream users, risk researchers, regulators and civil society). A clear identification of the innovation context for nanotechnologies, together with the interaction with various stakeholders, allowed us to identify specific challenges for co-creation. As indicated in the table above not all of the areas are likely to be improved by co-creation, but they nevertheless fundamentally define the context or final outcome of research and innovation processes.

SPECIFIC CHALLENGES FOR CO-CREATION

...WITH REGARD TO NANOTECHNOLOGIES

Based on the issues outlined above, nanotechnologies and nanomaterials are considered differently across industrial sectors and by different stakeholders. Therefore, a common understanding needs to be established in terms of:

- how to deal with uncertainties, mainly related to technical and scientific aspects, normative issues, ethical, social and environmental implications, and strategic and systemic aspects of research and innovation that all stakeholders along the research and innovation value chain face to some extent
- the state of the art of research activities and debate around the safety of nanomaterials and a normative framework for nanotechnologies
- the ambiguity of the debate around nanotechnologies, which is probably due to gaps in sharing of information among the different actors of the research and innovation value chain and to a shortage of reliable and acknowledged sources of information in the field (transparency)
- the difficulties in expressing, understanding and considering the needs, concerns and expectations (and perception of risks) of stakeholders (in particular citizens) in the course of nanotechnology development. This holds especially true for materials which involve radical innovations and are likely to have a significant impact on people and society (e.g. healthcare). In short, the issue of trust in nanotechnology innovation (by citizens, as well as by partners, suppliers, business operators and other stakeholders along the research and innovation value chain).

A lack of consideration of these aspects can easily polarise debate, hamper the relationships between stakeholders or cloud the dialogue with citizens. As a result, innovations can experience a slowdown or be side-lined. While there might be other reasons to be considered here (as required under RRI), the most important ones may come from the innovation stakeholder perspective.

... WITH REGARD TO CO-CREATION

The GoNano experience shows that there are challenges related to the implementation of a co-creation approach as such. In particular:

- a lack of awareness about the potential benefits of co-creation, which is associated with a lack of convincing and inspiring examples of how to include societal aspects and stakeholders' views in the development of new innovations. This then frequently results in overconfidence in one's own perspective and capacity to assess all aspects of the innovation process. The issue is therefore how to demonstrate the added value of co-creation approaches for innovation, in order to persuade research and innovation actors to use and implement such an approach.

- a lack of acknowledged and good practices for co-creation. Providing good examples or finding testimonials and “ambassadors” (who have already experienced co-creation) could reduce initial scepticism and improve stakeholders’ confidence, and it could also reduce the likelihood of barriers and expectations regarding co-creation being either underestimated or overestimated.

Co-creation projects are still in their infancy as a means of developing knowledge for social purposes. Most existing co-creation projects work on a local scale, seeking practical solutions that work for a specific product and service and for a specific organisation.

The following section identifies some of the existing conditions that make a case for increased efforts to introduce co-creation and stakeholder engagement approaches along the value chain on both organisational and systemic levels. These conditions are summarised in the second column of Figure 3.

To identify the areas of action for co-creation, there is a need for changes at the level of internal activities of organisations (e.g. commitment, relationships or procedures¹⁰), of cooperation throughout the innovation ecosystem (e.g. through policies or relationships involving more stakeholders or the public), and of policy actions. Suggestions from the GoNano experience are reported in the next section.

¹⁰ See also GoNano white paper 1: Rule of thumb ‘Enhance potential for recognition of opportunities’.

RECOMMENDATIONS FOR ACTIONS TO ESTABLISH CO-CREATION

The following recommendations have been derived from the GoNano findings. They may offer some support to those who would like to organise future co-creation processes along the research and innovation value chain, increase added value for all the stakeholders involved, and facilitate RRI-friendly conditions.

As co-creation is a complex approach requiring synergies between different functions of the organisation and stakeholders, adopting a structured management process could help to deal with it.

RECOMMENDATION 1: IDENTIFY NEEDS AND ENTRY POINTS FOR CO-CREATION

WHY?

It is important to collect, understand and consider the needs and views of the different stakeholders who are to be involved in the co-creation from the very early stages of the process, as the goal is to provide concrete added value to each stakeholder, thus motivating them to take an active part in the co-creation process. This will also make it possible to provide a better focus for the different phases of the process.

How?

Each organisation along the value chain should identify the research and innovation topics and motivations that are a priority for co-creation purposes, selecting areas where the organisation could provide valuable inputs and areas where the organisation needs to receive data and information from the co-creation process.

Specific recommendations to identify needs and areas of action for co-creation are:

- *Highlight the most interesting points to debate for each stakeholder (e.g. interests, needs and concerns)*
- *Identify criteria to prioritise topics/areas for stakeholder engagement*
- *Identify where in the value chain the co-creation could be most useful*
- *Select stakeholders to be involved in different co-creation phases*
- *Provide clear indications about the focus and priorities of co-creation actions*

Initially, GoNano consulted selected stakeholders (interviews) about their needs and views in order to inform the co-creation process. This action explored aspects related to the most significant ethical and social issues to debate, the added value of co-creation, and the type of stakeholders to involve. Most of the results of this exercise are quite specific for the type of application and sectors considered. As an example, the needs and concerns of stakeholders identified in the case of application of nanotechnologies in the health sector are reported in the figure below.

Moving to a systemic level, this will make it possible to draw up a list of key areas or topics that are relevant for the solutions being developed and for the stakeholders involved and will help identify those most relevant for the debate. A set of criteria could serve to prioritise the topics. Stakeholder engagement should cover the whole research and innovation value chain and may have different purposes for and involve different stakeholders. There could also be, for example, different sessions along the same co-creation process targeted to different steps of the value chain. At a systemic level, it should always be made clear to which stage of the value chain the respective stakeholder engagement is referring, while each organisation should clearly identify the important value chain steps to select the appropriate session or initiative.

The GoNano experience with one of the stakeholder workshops (GoNano D4.2, 2019) in the Dutch pilot highlighted that in that case participants had difficulty distinguishing the prototyping session from the ideation process, while in another workshop the purpose of the session was not clear. Such confusions can be avoided. In order to move the co-creation session forward from the ideation phase to the prototyping phase, a specific problem or goal should be defined. Preparation is crucial in this regard, and interviews with stakeholders before the workshop could help to establish a framework in which stakeholders are asked to come up with suggestions for action.

RECOMMENDATION 2: MAPPING THE INNOVATION CONTEXT

WHY?

In order to contextualise innovation, it is crucial to identify the Research and Development priorities of the sector in question. This can both provide a general idea of what innovators are considering at the present time and inspire possible future scenarios in the sector. The GoNano literature review and experience with stakeholder interviews and with citizen and stakeholder workshops confirmed that nanomaterials and nanotechnologies can contribute to providing solutions and products to address societal challenges as well as public and stakeholders' needs in the three areas considered: Food, Health and Energy. As an example, the specific applications and Research and Development priorities that were identified in (GoNano D1.3, 2018; GoNano D5.1, 2018), are shown in Figure 5.

"To map the innovation context seems to be crucial as the first step of the co-creation process – to be able to identify the application areas that seem to be most promising to be used in the near future. However, even in these specific areas, their perception may be ambivalent. On the one hand, the nutrition/novel foods application area was perceived as the most promising area connected to many expectations (citizen workshop). On the other hand, the very same application area was connected to the highest safety risks and difficult implementation in concrete products during the second stakeholder workshop." (co-creation pilot on food, Czech Republic)

| NANOTECH RESEARCH AND DEVELOPMENT PRIORITIES | | |
|---|--|--------------------------------|
| EMERGED FROM GoNANO LITERATURE REVIEW, INTERVIEWS AND WORKSHOPS | | |
| Food | Health | Energy |
| Packaging | Therapeutics: targeted and personalised drug delivery and theranostics | Energy storage |
| Safety & Security | Diagnostic/imaging: efficient fast and site-specific monitoring | Advanced photovoltaics and CPV |
| Nutrition | Regenerative medicine | Multi-application components |

Figure 4: Nanotech Research and Development priorities (see GoNano D1.1, 2018 and 1.3, 2018)

How?

A context analysis of the innovation eco-system in which co-creation is taking place should be performed, to inform and inspire both the planning and the implementation phase of the co-creation process. Context analyses need to explore a series of elements, such as the ones outlined in the table below as used in the GoNano project.

Recommendations on how to analyse the innovation context are:

- *Identify research and innovation priorities in the field*
- *Identify the research and innovation value chain*
- *Map the stakeholders in the innovation ecosystem (including end-users)*
- *Highlight type of business, market aspects, trends and consumer attitudes*
- *Identify relevant regulatory aspects*

As a value chain approach is recommended, it is crucial to identify and map all stakeholders (including the end-users) in the respective innovation ecosystem, i.e. highlighting their interests, relations, needs and concerns. It could also be useful to consider the type of business, the specific market characteristics, the trends and the consumer attitudes. Specific attention should be paid to identifying and analysing the regulatory aspects that could influence the innovation.

The GoNano project performed an analysis of these aspects with a specific focus on the three target sectors (Food, Health, Energy), as reported in (GoNano D5.1, 2018) and (GoNano D5.2, 2019). This analysis showed that issues of safety, regulatory constraints, stakeholder attitudes are quite relevant in the development of nano-related products. An example of the outputs of the context analysis in the case of the healthcare sector is reported in figure 5.

| CONTEXT FOR NANOTECH INNOVATION | |
|--|---|
| HIGHLIGHTS FROM THE HEALTH SECTOR | |
| Stakeholder of innovation ecosystem | Company (R&D, Quality and Management); R&D partners (research centres and academia, hospitals; business partners (public and private investors, suppliers); market clients and end-users (hospitals, healthcare professionals; patients associations, patients, advocacy groups); insurance, policy makers and regulators; society (media and the public) |
| Final/end users | Health care professionals and patients |
| Value chain relevant aspects | Complex value chain, long time to market to R&D (roughly 10 years or more from idea to market) |
| Relevant market aspects | The time to market of innovative solutions could be also a decade longer with respect to other sectors |
| Regulatory aspects | Stringent regulation, including regulatory oversight all along each of the steps of the R&D value chain. Specific requirements for nanomaterials in the medical devices' regulation |
| Type of business | Both Business to business and business to consumers |
| Trends or consumers attitudes | Demographic changes Benefits of healthcare products often outweigh risks |

Figure 5: Context analysis for nanotech innovation in the health sector (see GoNano D5.1, 2018 and 5.2, 2019)

RECOMMENDATION 3: SHOWCASE BENEFITS OF CO-CREATION

WHY?

Our analysis suggests that individual researchers can benefit from opening up to broader perspectives. Extending partnerships beyond the usual suspects to include a broader range of stakeholders could both create new business opportunities and function as early warning for potential problems further down the line.

It also allows researchers to modulate research trajectories as they unfold, rather than after they are established (for more information see the GoNano Website).¹¹

How?

In order to motivate less experienced stakeholders to participate in co-creation processes, particular strategies may be deployed. However, the challenge in this process is to educate/inform the participants without undermining their values and concerns.

Pilot Food

“Stakeholders repeatedly emphasised that the main benefit of the co-creation process is that they can meet and discuss ideas or products they work on with experts with a completely different perspective, and that these meetings and exchanges of ideas are something they lack. During one of the workshops, a representative of a state said that this was the first time they had met at one table various actors actually engaged in the development of specific products.” (co-creation pilot on food, Czech Republic)

Pilot Health

The GoNano stakeholder workshops do, in some cases, suggest added value for the researchers involved. According to the developer of the artificial pancreas, for which a data-management plan was formulated, the outcomes of the workshop *“improved the foundation of their product as there were some new aspects discussed they hadn’t thought of before”*.¹² The developer of the early diagnostic device for which an implementation plan was discussed evaluated the outcome as something that supported their initially somewhat vague ideas, which had since become much clearer. They thought the discussion with participants from different backgrounds was *“very stimulating and motivating”*. Another example was derived from collaboration with a post-doctoral researcher at the start of their research trajectory who was focusing on the diagnosis of cancer based on specific proteins. By discussing their proposal with different stakeholders along the value chain, the researcher got new insights into how to further develop their research. These included reshaping the demand for their research by talking to other stakeholders. For the post-doc researcher, the workshop exceeded their expectations as they got a *“more concrete understanding of what steps to take and what steps not to take during the rest of their research”*, which helped them *“to build the next three years of my research life”*.¹³

¹¹Please see: https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P_PU_m-d [2019-01-16] (30-06-2020).

¹²Please see: https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P_PU_m-d [2019-01-16] (30-06-2020).

¹³Please see: https://www.youtube.com/watch?v=1UbBVtbiNdM&list=PLI2-pUcVlb7Mub_FgxtwLpQZCzbHHZBOW&index=4&t=1s (30-06-2020).

“One of the important points to emphasise seems to be that nanotechnology in itself is connected to various fields of expertise: from biotechnology, materials science, conservation of food to circular economics. If not for anything else, the main benefit is that there is a topic which brings all these actors to one table and ensures that there is a possibility to come up with as complex solutions to current problems as possible.” (co-creation pilot on food, Czech Republic)

In addition to this, some agreements about future collaboration were reached with the participants present at the workshop.

Recommendations to showcase benefits of co-creation:

- *Researchers should be informed as to the rationale of co-creation, that is, why they should be involved in co-creation exercises.* Innovators, including researchers, may be unaware of the implications of demands for sustainable, desirable and acceptable advances in science and technology for their innovations and processes. Co-creation events offer opportunities for the articulation and deliberation of the needs and concerns of society and contribute to the development and embedding of new, more desirable advances.
- *Provide examples to clarify how stakeholder engagement can enhance both the quality and the societal value of research and innovation.* Additional efforts are needed to make existing experience more accessible and actionable, with respect to when and where stakeholder engagement makes sense and how it can be organised.

RECOMMENDATION 4: IMPLEMENT A STRUCTURED METHODOLOGY FOR CO-CREATION

WHY?

The objective of the co-creation process is to bring together very different views and perspectives, taking into account a variety of issues about the specific technology or innovation and considering that stakeholders often speak completely different 'languages'. Accounting for the various perspectives, in a space where all stakeholders feel safe to express their views and where these views are heard and considered, requires deliberate consideration of obstacles and the limitations and interests of all groups involved, which, in turn, requires approaching the process with a clear sense of how to overcome these hurdles. Therefore, it is essential to have a structured and well-defined methodology in place, that will ensure a smooth and effective co-creation process.

How?

Although there are many methods out there (see figure 6 below), the right choice and implementation is crucial and hence needs adequate consideration. The notion of co-creation (and stakeholder engagement) is an umbrella term that groups together a wide range of activities on different levels, from formal social dialogues at the European level, to living labs at the local level and human-centred design approaches within individual organizations, just to provide some examples.

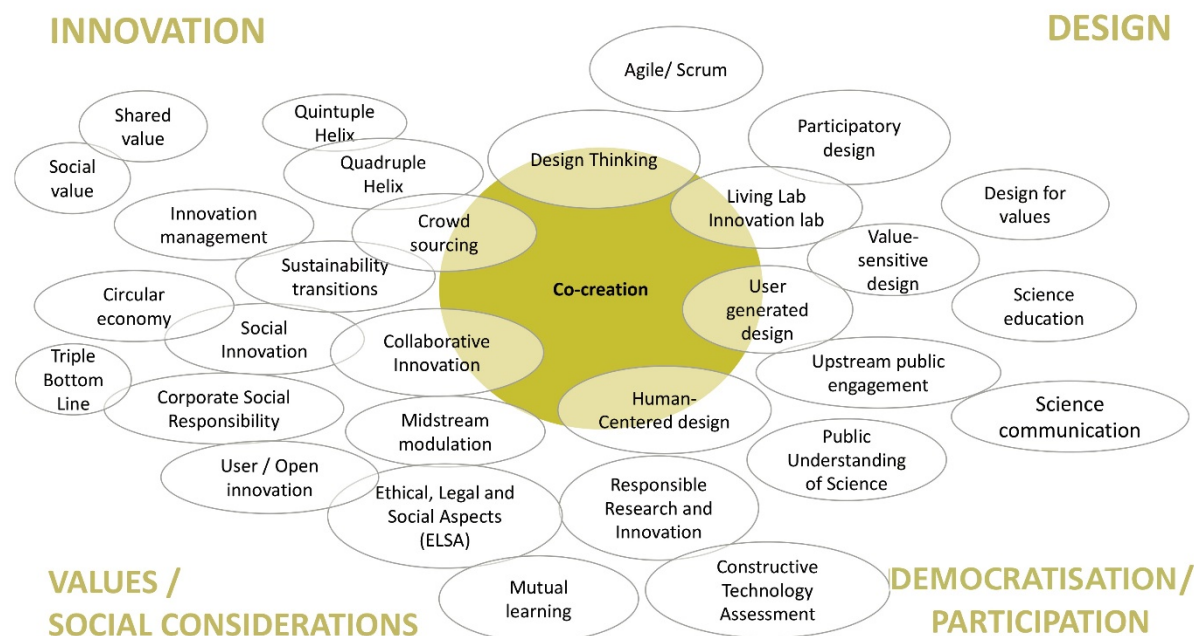


Figure 6: Different ways of interpreting integration of stakeholder perspectives and stakeholder engagement in a co-creation process for innovation

The organisation (or organisations) aiming to implement co-creation approaches should analyse and identify the most suitable methodologies for the specific Research and Development value chain stages and actors. GoNano explored a series of methodologies for co-creation provided in the literature used by different stakeholders and developed and tested its own specific methodology.

Recommendations about the methodology for co-creation are:

- Plan your co-creation process in advance, including timeline, type and purpose of engagement activities, recruitment strategy, guidance for participants, templates for reporting, follow-up initiatives
- Search for good practices available in literature
- Engage with experts to provide you advice and assistance in the co-creation process
- Develop Key Performance Indicators to regularly monitor and improve the efficiency and efficacy of the co-creation process

The GoNano project designed a recruitment strategy, workshop manual, and information material tailored to the needs of citizens and stakeholders (GoNano D3.2, 2019).

This suggests that it is important to have a structured methodology to follow in a stakeholder engagement process. The methodology could be developed by the organisation itself, but the advice of external experts is recommended in order to focus the objectives and maximise the outputs, in particular when the number of stakeholders to be involved or their heterogeneity increases.

Experts could be, for example:

- A facilitator who understands the topic, the process and how to facilitate open and constructive discussions
- An organiser, who has a broad network and is creative in combining the very best stakeholders for this methodology
- Co-creation experts, who understand the process and know which tools are available and suitable for various steps of the workshop and how get the most out of it
- Experts from other fields, such as an illustrator to make visual notes who is able to translate and visualise the various steps for final presentation, for next steps and/or for dissemination activities.

Moreover, GoNano engaged an external advisor to perform an assessment of the co-creation process, based on tailored key performance indicators. These included qualitative and quantitative indicators to measure the efficacy and efficiency of the co-creation process, monitored by surveys and interviews to partners and participants of the co-creation initiatives. Regular feedback was provided to partners by the external advisor in order to improve the impact of GoNano activities (see GoNano D8.3, 2019).

RECOMMENDATION 5: BALANCE CO-CREATION AND RESEARCH AND INNOVATION OBJECTIVES

WHY?

The GoNano experience highlights a contrast between two different rationales for co-creation: “opening up” and “adding value”. The first rationale seeks to include heterogeneous stakeholders (including those not normally included in research and innovation), with the aim of brainstorming about possible future applications and collecting as many values and needs as possible in order to inspire new possible research trajectories. The second rationale is a convergent process involving more specific stakeholders (such as prospective users) with the aim to focus research trajectories towards concrete products and improvements (e.g. making them more efficient, cheaper or more resilient).

While ‘opening up’ is essential to collect societal inputs, ‘adding value’ is essential to translate this knowledge in products that will return value to society. Both are needed for a co-creation process that seeks to align research and innovation with societal needs and values: focusing only on “opening up” will result in a theoretical exercise, while focusing only on “adding value” would preempt the responsiveness of the innovation process. See also GoNano D4.4, 2020, p.20: *“Both rationales have played a role in the design of the GoNano project and the results of the workshops suggest opportunities for both. For instance, the consideration of the wishes, needs and messages from citizens during the first stakeholder workshop suggest how research trajectories can be ‘opened up’ to societal considerations. [...] However, the GoNano experience suggests that perhaps it is too much to expect both objectives to be addressed simultaneously. [...] The desire to ‘add value’ to concrete research lines may come at the cost of ‘opening up’ research and innovation, and vice versa.”*

How?

Ideally, the co-creation process should thus combine both rationales. However, this entails much longer timeframes than those experienced in GoNano. It is crucial to find the right balance between “opening up” and “adding value” in the co-creation process and to align these rationales with the timeframes of the research and innovation process.

Recommendations on how to balance co-creation and research and innovation objectives are:

- to combine stages of ‘opening up’ and ‘adding value’ in an iterative way.
- to align the different phases with the different steps of the research and innovation process (also considering the issues to be addressed in the different phases and the stakeholders to be involved).
- to guarantee continuity of the co-creation process in parallel with the research and innovation process, for example by ensuring that the results of a previous phase are usable in the next phase (if suggestions from citizens are formulated at a high level of abstraction it is crucial to translate them in intelligible requests for developers in the prototyping phase) (see also white paper 1).
- to use adaptive approaches to the co-creation process, for example using the outcomes of an initial step to design the next steps (in terms of objectives, stakeholders, and expected outcomes).

The multi-stakeholder conversations during the first stakeholder workshops indicated that research trajectories can be effectively opened up to societal needs and values. The second stakeholder workshops suggested how societal needs could add value to the development of specific products, as for example in the case of the wireless sensor nodes for the future Internet of Things discussed in the event on energy held in Spain. Hence, both rationales have played a role in the design of the GoNano project. However, the GoNano experience suggests that perhaps it is too much to expect both objectives to be addressed *simultaneously*. Ideally, co-creation processes iteratively combine activities towards 'opening up' and 'adding value'.

RECOMMENDATION 6: ENSURE UNDERSTANDING BETWEEN PERSPECTIVES OF RESEARCHERS, STAKEHOLDERS AND SOCIETY

WHY?

Translation of needs and perspectives of stakeholders within and between different stakeholder groups such as researchers, industry, and citizens are key to identifying potential social impacts of research and innovation, and translating them into research questions to address.

It is important to consider how to translate societal considerations into information that can have a bearing on concrete research decisions, as societal feedback might not fit frictionless into research scope, either because it is frequently not concrete enough or because it might lead to contradictory responses.

HOW?

From the citizens' side, insight into the individual, day-to-day decisions being taken in nanotechnology research and innovation is required (and respect for the limited room for manoeuvre at that level). From the researchers' side, an understanding of public perceptions of and attitudes towards nanotechnologies is important, as well as an understanding of the rationales underpinning them. From the industrial side, it is important to clearly communicate what information can be shared with others and what cannot be shared, e.g. due to confidentiality issues, to understand public perceptions with respect to the industrial development process and its mission and values, and also to assign the right priority to citizens' requests.

It is crucial for the process to allow participants to build a relationship and develop a shared language in which their contribution to the problems at hand can be meaningfully expressed. Similarly, the capacity to translate needs and concerns from the social realm into practical options in the technological realm in real time is essential to the success of the process.

These are tall orders indeed, but this is exactly what needs to happen to realise the policy prescriptions underlying the notion of Responsible Research and Innovation and the Science in Society movement in general: *"to encourage actors in their own disciplines and fields to participate in developing Science in Society perspectives from the very beginning of the conception of their activities."* (European Commission, 2007)

More specific recommendations to ensure understanding between the different actors involved, and more in general to improve the efficacy and efficiency of the co-creation process, are described in GoNano white paper 1 and 3. These include suggestions on how to design co-creation processes to take into account gender, diversity and culture aspects, and how to increase motivation, recognize opportunities and build trust among participants of the co-creation process.

RECOMMENDATION 7: CREATE A CULTURE OF CO-CREATION

To facilitate the changes necessary to promote the consideration of ethical and social impacts, and to pursue co-creation, changes need to be made to research cultures and to the incentive structures of researchers. This point is crucial in research organisations (public or private) as well as in industry while realizing that these aspirations may still be developing in practice. Therefore, this recommendation can be considered an attempt to promote mainstreaming of co-creation practices.

WHY

GoNano's work on taking stock and reviewing prior findings and engagement processes (GoNano D1.1, 2018), as well as integrating stakeholder perspectives (GoNano D1.3, 2018) has delivered an analysis of the current status of the RRI landscape. In the synthesis with the GoNano experiences (as outlined in (GoNano D4.4, 2020, p.32), the project *"has revealed important insights into the requirements for a more responsive research and innovation system. What is ultimately at stake in the question of enhancing responsiveness is the very way in which we understand innovation - from static, closed linear models towards responsive innovation that addresses the pressing societal challenges of our time. (...) The question is how to enable new models of innovation that integrate societal considerations earlier and more effectively in the research and innovation process. These insights align well with the findings of other European projects: they point to opportunities and preconditions for strengthening responsiveness, but they also highlight the complexities of promoting cultural change in research and innovation systems."* (GoNano D4.4, 2020).

Among the projects identified, especially the RRI-Practice project¹⁴ has investigated the role of RRI in research funding and research performing organisations and reflected on the barriers and drivers regarding RRI in these organisations. The project found that, while responsibility norms associated with research (e.g. research ethics, integrity and open access) were, generally, established and codified in most of the organisations, the additional responsibility implied by RRI – including responsiveness – tended to be poorly articulated and codified in the organisations.

There was *"very little evidence of knowledge co-creation and co-production that accord with the EC's broader definition of and ambition for RRI"* (Owen et al., 2019, p.3). Although there was evidence of some *"small scale, creative and inspiring experiments, these tend to be modest, time-limited and not routinely or systematically embedded and sustained in organisations"* (Owen et al., 2019, p.3). This was due to a number of major barriers including entrenched norms, political pressures and priorities, *de facto* reward structures that do not take this kind of work into consideration, and a lack of training and infrastructure. At the same time, one sees the introduction of external forms of responsibility thinking (around integration and other similar notions) into organisations via specific organisational activities, projects or funding initiatives without significant conflict, while internal orientations rooted in the "republic of science" model remain dominant in overall practice, structures and cultures (Hennen et al., 2019).

¹⁴ <https://www.rri-practice.eu/> (30-06-2020).

Another important finding of the RRI-Practice project concerns notion of excellence and impact that condition performance evaluation and criteria for career progression at organisational and national levels (Owen et al., 2019). The project encountered narrowly defined understandings of research quality and excellence that are at odds with calls to do RRI or to be 'responsive', as RRI is viewed as diverting attention and time from the pursuit of excellence.

It is important to identify and highlight the added value for each stakeholder in the innovation ecosystem. Inside the single organisation, the individual evaluation should include criteria that include the ability to integrate different perspectives and being responsive.

How?

A tension exists between the *de facto* incentives and disincentives that form the basis of the science system and new funding mechanisms that promote efforts to address grand societal challenges through interdisciplinary and cross-sectoral research, including co-creation. While research funders continue to promote such collaborative initiatives, evaluations of researchers and research are still predominantly based on criteria of scientific excellence or the marketability or valorisation of research (van den Hoven et al., 2013). Thus, funders have a key role to play in reconfiguring both the incentive structure and the corresponding evaluation mechanisms in the research system. Currently, there is no reward for engaging stakeholders in the research system (van den Hoven et al., 2013). Without a clear mandate or obvious benefits, it may prove difficult to embed stakeholder engagement in the everyday practice of European research and innovation.

REFERENCES

- Collingridge, D. (1980) *The social control of technology*. Pinter, London.
- Compass project. (2019). *Deliverable 1.4: Integration of the RRI approach into collaborative R&D&I and SME participation in European funded collaborative research in healthcare, nanotechnology and ICT*.
- DG for Research and Innovation Key Enabling Technologies. (2018). *Re-finding Industry, Defining innovation: Report of the independent High Level Group on industrial technologies*. Publication Office of the European Union .
- European Commission. (2007). *Work programme 2007, Capacities, Part 5, Science in Society. C(2007)563*.
- European Commission - Directorate General for Research and Innovation. (2019). *100 Radical Innovation Breakthroughs for the future, Independent Expert Report*.
- Genus, A., & Stirling, A. (2017). Collingridge and the dilemma of control: towards responsible and accountable innovation. *Research policy*, 47, 61-69.
- GoNano D1.1 (2018) *Deliverable 1.1: Building on the state-of-the-art: ex-post evaluation on mutual learning*. Brussels: GoNano project.
- GoNano D1.3. (2018). *Deliverable 1.3: Stakeholders on engagement in nanotechnologies: Areas and issues for dialogue*. Brussels: GoNano project .
- GoNano D2.1. (2018). *Deliverable 2.1: Method and manuals for the pilot studies: towards a GoNano co-creation approach*. Brussels: GoNano project.
- GoNano D3.2. (2019). *Deliverable 3.2: Deliberating and Envisioning workshops with citizens*. Brussels: GoNano project.
- GoNano D4.2. (2019). *Deliverable 4.2: Working paper on the designs and outcomes of workshop round 1*. Brussels: GoNano project.
- GoNano D4.4 (2020) *Deliverable 4.4: Final report on the insights and lessons from the engagement activities*. Brussels: GoNano project.
- GoNano D5.1. (2018). *Deliverable 5.1: Risk governance and research & innovation priorities in nanotechnologies*. Brussels: GoNano project.
- GoNano D5.2. (2019). *Deliverable 5.2: Risk Governance and research & innovation priorities in Nanotechnologies, 2019 update*. Brussels: GoNano project .
- GoNano D8.3. (2019). *Deliverable 8.3: Evaluation strategy and indicators for the GoNano project activities and impacts*, Brussels: GoNano project

- Hennen, L., Damianova, Z., Egeland, C., Grinbaum, A., Hahn, J., Hajdinjak, M., Ladikas, M., Ludwig, D., Macnaghten, P., Magaudda, P., van der Molen, F., Neresini, F., Owen, R., Pansera, M., Politi, V., Pols, A., Shelley-Egan, C. (2019) Implementing RRI: Comparison across case studies, RRI-Practice project report. Deliverable D15.1.
- NANO futures, European Technology Integrating and Innovation Platform on Nanotechnology. (2015). *Implementation Roadmap on value chains and related pilot lines*.
- Owen, R., Forsberg, E-M., Shelley-Egan, C. (2019). RRI-Practice Policy Recommendations and Roadmaps, RRI-Practice project report. Deliverable 16.2.
- Rip, A. (2014). The past and future of RRI. *Life Sciences, Society and Policy*, 10(17), 1–15.
- Tuncak (2013). *Driving innovation: How stronger laws help bring safer chemicals to market*. Available at https://www.ciel.org/Publications/Innovation_Chemical_Feb2013.pdf

3.3. WHITE PAPER 3



The importance of gender and diversity in nanotechnology Research and Innovation

*GENDER, DIVERSITY AND CULTURE
IN NANOTECHNOLOGY RESEARCH AND INNOVATION:
POLICY RECOMMENDATIONS FOR DESIGNING ENGAGEMENT PROCESSES*

| | |
|--------------------------------|---|
| Editors: | Ulrike Bechtold and Daniela Fuchs (OeAW) |
| Compiling author(s): | Vanessa Moore (EIWH), Lise Bitsch (DBT) |
| Contributing author(s): | Marek Pour and Lenka Hebáková (Technology Centre of the Czech Academy of Sciences, TC CAS), Sikke Jansma and Anne Dijkstra (University of Twente, UT), Craig Richmond (European Office of the Royal Melbourne Institute of Technology, RMIT), Maud Bomert, Hannie van den Bergh and Daan Schuubiers (DPF), Harald Throne-Holst, Clare Shelley-Egan (OSLOMET), Daniela Pimponi and Andrea Porcari (Airi) |

CONTENT

| | |
|---|----|
| Foreword | 6 |
| What are the GoNano white papers? | 6 |
| GoNano project and goals | 7 |
| Why the gender dimension and diversity matter | 10 |
| Sex versus gender | 10 |
| The relevance of the gender perspective on nanotechnologies research and innovation..... | 11 |
| Taking gender into account in the GoNano co-creation process..... | 11 |
| Gender versus diversity..... | 11 |
| Gender and gender equality..... | 12 |
| Citizens and consumers – another facet of taking on roles in society | 12 |
| Policy recommendations for better consideration of gender equality, diversity, culture and communication..... | 14 |
| Recommendation 1: Strengthen gender mainstreaming from the outset | 15 |
| Recommendation 2: Include diversity from the outset | 18 |
| Recommendation 3: Adopt a strategic approach to engagement and a two-way communication effort | 21 |
| Recommendation 4: Visualise future applications in everyday life contexts | 23 |
| Recommendation 5: Challenge implicit discrimination and gender issues..... | 25 |
| References..... | 26 |

EXECUTIVE SUMMARY

Inequality issues of gender and diversity have been increasingly recognised within research and innovation as both a normative challenge and a limitation to innovation. It is argued that dealing with these issues allows increased innovation capacity and provides opportunities for nanotechnology-enabled products to be better aligned to societal needs and values. Thus, balancing these inequalities has been considered a crucial challenge in the framework of Responsible Research and Innovation (RRI).

RRI claims that it will be able to foster innovation that is safe, ethically acceptable, and responsive to the needs and expectations of people; it aims at redistributing responsibility among *all relevant* actors to align their input closer to innovation processes in a non-discriminatory way. As a result, sensitivity towards gender and diversity and towards culture and communication require special attention.

In the GoNano project we aimed to show how co-creation, as a method and process, could be used to include reflections on gender and diversity in state-of-the-art research and innovation activities. Our demonstration tool place through three pilot studies investigating the potential of co-creation between citizens, researchers and other professional stakeholders on the topic of future nano-enabled technologies in food, energy and health.

Based in our experience, we have developed five recommendations for mainstreaming considerations of gender and diversity issues and of culture and communication in research and innovation trajectories. The GoNano white paper identifies opportunities and challenges related to this goal and aims to provide interested parties (e.g. organisers of such processes) with hands-on recommendations for what to consider when thinking about implementing such a co-creation process.

The five GoNano recommendations for strengthening awareness of sensitivity with regard to gender, diversity, and culture and communication are:

1. *Strengthen gender mainstreaming from the outset*

Allow for flexibility in thinking and avoid stereotypes. Individual inputs and viewpoints should be encouraged which differ from the norm and the mainstream, by informing the participants using various examples (for example diverse perceptions of risk, nano and religious beliefs) and reflecting with them on how diversity and gender play a role in the process. Taking diversity and gender into account strengthens the plasticity and lifelines of the discussion and process, but it requires some extra effort regarding the selection of stakeholders and experts and the decoding of gender aspects in the actual content of the workshop.

2. *Include diversity from the outset*

A lack of diversity within a community (here: the nano community) disadvantages those who are in a vulnerable and 'not-normative' position in a societal or global context (historically and at the present moment), as their needs and values are not sufficiently (i.e. equally) represented in a way that would provide for equality. GoNano considers that a

wide range of opinions should be included in research and innovation as a desirable societal norm. However, apart from humanistic ideals, encouraging diversity in science, engineering and other work contexts has been shown to create smarter and more creative teams with more output and is therefore also a profitable approach, even if deviations within groups remain small.

3. *Adopt a strategic engagement and a two-way communication effort*

To adopt a strategic engagement and a two-way communication effort, it is important to have an idea of how a lay person may come to reach an opinion on nanotechnology. Once this is ensured, the next step is that the information material individuals are presented with is appropriate, respecting differing cultural and intersecting social identities. This ensures that as many opinions as possible are captured and appropriately presented, and that questions important to different demographic groups are included.

4. *Visualise future applications in everyday life contexts*

Especially when discussing the subject of nanotechnology, visualising future applications in everyday life contexts may enhance debates. Because nanotechnology is inherently abstract, it is often difficult for lay people to imagine some aspects of it. Concrete examples help to ensure that lay people can converse about and discuss the issues with scientists, stakeholders and other participants as equals. In GoNano, a special emphasis was put on tangibility of ethical and societal challenges with all participants in the process. In order to cope with this concern, possible scenarios were developed and provided in the workshops and also in the information leaflets.

5. *Challenge implicit discrimination and gender issues*

Visions of nanotechnology include subtle assumptions regarding gender and diversity implications. However, visions, prejudices and projections are highly subjective. Therefore, it is important to envisage the potential actors, their reactions, and their behaviours and to reflect and challenge existing assumptions or stereotypes. However, this policy advice is not only a specific best practice suggestion for nanotechnology processes but also a key element of best practice in science and communication in general.

FOREWORD

WHAT ARE THE GONANO WHITE PAPERS?

The present publication is part of a series of three white papers developed by the GoNano project, covering different aspects of co-creation in research and innovation, with a focus on nanotechnology.

The white papers are intended as a knowledge repository for further GoNano communication activities. As such, they provide relevant background information with condensed GoNano findings. They also form the basis for six policy briefs and two industry briefs outlining the topics with policy and industry relevance.

The three GoNano white papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnologies. Each paper addresses the question of Responsible Research and Innovation (RRI) in nanotechnology research and innovation from a different angle.¹

- White paper 1 explores the opportunities and drawbacks of using co-creation as a tool to enhance the responsiveness of nanotechnology research and innovation to societal needs and values. The white paper highlights the findings from the GoNano co-creation process and suggests five rules of thumb for prospective co-creation practitioners. It is mainly targeted at researchers, engineers and other stakeholders involved in research and innovation.
- White paper 2 provides insights on *how to implement co-creation*, considering research as well as the innovation ecosystem. It addresses industrial and business partners, research institutions, and policy makers involved in research and innovation.
- White paper 3 provides guidance on how to realise co-creation in the light of a *gender and diversity perspective* in order to better integrate these perspectives into nano-related research and innovation. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

¹ For more information on the RRI framework by the EC please see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>) (30-06-2020). For the aspect of responsiveness please see GoNano white paper 1.

GoNANO PROJECT AND GOALS

This white paper explores opportunities and constraints for implementing co-creation in nanotechnology research and innovation practice. It builds on the findings of the GoNano project, which is based on the assumption that several types of knowledge and expertise are needed to support co-creation towards sustainable, acceptable, and desirable applications of nanotechnologies. GoNano explored approaches that could be put into practice in different application areas of nanotechnologies (Health, Food and Energy), combining face-to-face citizen consultations, stakeholder workshops and online consultations (see Figure 1).

There has been growing interest in co-creation in recent years. Generally speaking, co-creation is defined as the practice of collaborative product or service development, as developers and stakeholders work together; or the joint creation of value by the company and the customer; or as allowing the customer to co-construct the service experience to suit their context.²

Co-creation as a method has been applied to research and innovation to achieve very different aims and objectives. Companies have used co-creation to encourage user-led innovation. Their aim is to put the needs of users at the heart of innovation. The Creator Space initiative launched by BASF, for example, aims to foster open innovation within the company.³

Others have used co-creation to enable more democratic decision-making in research and innovation. The EU project Making Sense EU, for example, helped citizens to use academic technologies to make sense of their own environments.⁴

Within the GoNano project, co-creation is applied to strengthen the ability of research and innovation processes to respond and adapt to changing demands. The underlying assumption is that research and innovation will be more socially robust if societal needs and values are considered in the early stages of innovation.

² For further information see GoNano D2.1(2018) or, for an illustrative example, see experiences of the Fonteer project: https://www.youtube.com/watch?v=VlD2EyW5W_k (30-06-2020).

³ The Creator Space initiative brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes. Originally developed as a one-time initiative to celebrate the 150th anniversary of BASF, the Creator Space now forms an integral part of the company's approach to innovation (in this YouTube video, Elise Kissling, Director of the Creator Space frontend innovation program at BASF, reports on Creator Space: <https://www.youtube.com/watch?v=Y0JuOWO0hB8>) (30-06-2020).

⁴ Using low-cost, open-source technologies, Making Sense EU empowered citizens to discuss methodologies, devise data collection strategies for measuring air pollution, water quality or sound pollution, and interpret the results. It's a win-win project: scientists can use the datasets for their research, and citizens acquire tools to understand their environment and take appropriate action. In this YouTube video Frank Kresin, Managing Director of the Design Lab at the University of Twente, highlights Making Sense EU: <https://www.youtube.com/watch?v=au3uVptWJbU> (30-06-2020).

GoNano defines co-creation as “activities [that] enable productive collaborations between researchers and societal stakeholders over longer timeframes, focusing on specific nanotechnology research lines, leading to tangible outcomes such as a new research avenue, proposal, product or prototype”.⁵ (GoNano D2.1, 2018)

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims to anticipate contributions that can serve to make research and innovation more socially relevant.

To do so, co-creation approaches require new forms of collaboration that extend across different disciplines and sectors. (Figure 1)



Figure 1: GoNano co-creation process

THE PROCESS IN DETAIL

GoNano has established an iterative and interactive process through which societal considerations in the area of nanotechnologies ⁶ can be integrated into research and innovation. In a series of citizen workshops, citizens expressed their wishes and concerns with respect to each of the application areas. In a series of stakeholder workshops, stakeholders subsequently explored ways to take these wishes and concerns into account in nanotechnology research and innovation.

⁵For further information, see this earlier report on the co-creation methodology for GoNano: D2.1(2018)

⁶ See GoNano D1.1(2018) and 2.1(2018) for knowledge base and the methodology developed in earlier stages of the project.

At the start of the iterative and interactive process, the three pilot partners (the University of Twente in the Netherlands, the Technology Centre of the Czech Academy of Sciences in the Czech Republic, and the European Office of the Royal Melbourne Institute of Technology in Spain) organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018.⁷ The aim of the first round of stakeholder workshops was to come up with concrete responsive design suggestions that could be fed back into ongoing research and innovation activities, building on the outcomes of the citizen workshops. The design suggestions were to feed into a next round of citizen consultations, which would again feed into a second round of stakeholder workshops serving to evaluate the uptake of the responsive design suggestions of the previous round. The primary aim was to identify product suggestions which are better aligned with societal needs and values. Taken together, these iterative tasks explore the potential of co-creation in integrating societal values in research and innovation and provide more insight into the more actively-oriented responsiveness of business and industry.

FINDINGS

GoNano elucidated opportunities and challenges of co-creation. The GoNano experience offers insights in the potential value of co-creation: participants valued the general opportunities for mutual learning and networking. However, getting from constructive dialogue to practical action remains a significant bottleneck. The gap between the appreciation of broader issues around research and innovation and the actual integration of those issues in daily research practices and priorities remains significant.

The GoNano experience suggests that co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, ‘translate’ needs and concerns from the social realm to practical options in the technological realm, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

Aligning research and innovation to societal needs and values is not just a matter of deciding what sorts of future applications European citizens and stakeholders *want and need* (which is difficult enough, given widely divergent responses). It is also a matter of *practically realising* the desired change. Due to the relative autonomy of the research and innovation system, calls for responsiveness will need to identify the win-win opportunities where ‘doing good’ and ‘doing well’ coincide.

For further information on the individual steps (citizen workshop, first stakeholder workshop, online consultation, second stakeholder workshop) please see GoNano D4.4, 2020.

⁷ See the briefing report for further information on the outcomes of the citizen workshops. (GoNano D3.2, 2019)

WHY THE GENDER DIMENSION AND DIVERSITY MATTER

The present white paper introduces rationales for *why*, and policy recommendations for *how to* realise an increased focus on gender, diversity and culture in nanotechnology research and innovation contexts and processes. Gender and equality are both highly relevant to RRI and nanotechnology, as this white paper will show. For example, teams have been proven to benefit from diversity, including gender, ethnicity, nationality, scientific discipline and work experience, to name only a few aspects (Nielsen et al., 2017). It is important to highlight that while the term ‘gender’ is used throughout this white paper, we use it to refer to ‘gender equality’ as opposed to the semantic meaning of the word ‘gender’. In terms of gender specifically, research focusing on gender aspects in nanotechnology and related fields is rare (European Commission, 2011).

The lack of inclusion of a gender approach from the very outset in relation to new technologies such as nanotechnology ultimately affects the outcome of the process (European Commission, 2011). RRI as a concept builds on previous governance frameworks that have dealt with uncertainty and a lack of knowledge about the effects of science, technology and innovation (Owen et al., 2012). In contrast to earlier research and governance frameworks, RRI is concerned about both the negative and positive consequences of science and technology development and innovation, and it promotes collaborative attitudes and orients itself towards possible future consequences in a prospective and proactive way. It builds on traditional governance instruments (hard and soft law) but emphasises the notion of self-regulation as key to responsibility in RRI.

As a concept, RRI is inherently normative when it comes to the goals it aims to achieve and the processes it would like to facilitate. As such, RRI can be understood as a holistic integrative approach in which gender equality and the gender dimension more broadly play an important role. The issue of gender equality is the second among the core issues (six keys) of RRI as defined by the European Commission, after public engagement and followed by science education, open access, ethics, and governance (Strand et al., 2015).

In line with the normative setting of RRI, GoNano as a project has taken on the agenda of raising awareness of issues of gender equality and diversity and outlining ways of addressing these issues. Thus, this white paper is focused on gender, diversity and related concepts and also addresses practical implications such as culture and communication in the area of nanotechnologies.

SEX VERSUS GENDER

One of the fundamental conditions shaping our social behaviour is our gender identity: however, in research and public discourse the difference between biological sex and socially constructed gender complicates the tasks of addressing the issue of identity (Deutsch, 2007). The term gender is not the same thing as biological sex; however, the two are often mistakenly used interchangeably. Gender refers to the socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women, whereas sex refers to the biological and physiological characteristics a person is born with (World Health Organisation, 2010). It is also important to note that neither sex nor gender is exclusively binary (male or female, man or woman); a person can for example be intersex, or identify on a broad gender spectrum. This is relevant to GoNano on several levels: first, the quota and role of women in STEM (Science, Technology, Engineering and Mathematics) research, as well as gender representation in the concrete co-creation process. Thus, the entire nanotechnology realm profits from incorporating a holistic gender perspective.

THE RELEVANCE OF THE GENDER PERSPECTIVE ON NANOTECHNOLOGIES RESEARCH AND INNOVATION

Nevertheless, the question of women in science, especially with regard to STEM fields is of great importance because as things stand the core values and assumptions in STEM fields, including nanotechnology, have been fundamentally shaped by men and male norms (Savath and Gage Brainard, 2013). The European Commission eloquently describes the issue with the help of the example of product customisation: “One very powerful idea, for instance, is that of product customisation, which means paying more attention to the specific needs of each individual user. These individuals are not necessarily average white males, but can be women, children or people with disabilities, and can have all sorts of ethnic and genetic make-ups, cultural and social backgrounds, etc. They all still have the right to see their specific needs addressed.” (European Commission, 2011, part 3.2) The gender imbalance has the effect of excluding women’s voices from the STEM fields, including nanotechnology, whether as academics, researchers, innovators, consumers, or product end users, to name but a few roles. Having a field as large and as important as STEM, and specifically nanotechnology, dominated by male norms means that balance and innovation are affected and thoughts and concerns that question the status quo are all silenced; this in turn contributes to one-sided research, poor innovation and inferior products in relation to co-creation and engagement. These considerations may also be reflected in addressing the diverse needs of citizens/consumers in relation to social, cultural and biological diversity (gender, ethnicity, age and other factors).

TAKING GENDER INTO ACCOUNT IN THE GoNANO CO-CREATION PROCESS

The GoNano project strove to implement gender equality from the very outset of the project. The issue of gender was therefore at the forefront in the partner workshops.

All workshops had a fairly good gender ratio, considering how male-dominated the area generally is. Because of the high intensity of discussion and fast pace of discussion, it was not possible to always keep track of exactly what role, if any, gender played between the participants. Nevertheless, the issue of diversity comes up throughout discussions in the sense that workshop participants are encouraged to think in terms of societal issues and how to solve them and to include citizens’ ideas and concerns. This is crucial and shows that diversity (of gender, but also of ethnicity, education, etc.) is essential to get the co-creation process going right from the start and to get an end-product that will be beneficial and does what it sets out to do. (‘Working paper on GoNano stakeholder workshops’ (D4.2, 2019))

GENDER VERSUS DIVERSITY

Being related but not limited to the concept of gender, diversity can be an even more difficult term to define – does it refer to gender, ethnicity, sexual orientation, age, ability, religion, social class? Diversity can mean many things, and a person may be diverse in one way and not in another.

For example, does including a woman on a team make it diverse, even if she is from a privileged, white middle-class background? Or is a team more diverse if it includes a middle-class man but one who comes from a minority background?

When considering such questions regarding diversity, it is crucial to look at how these multitudes of social identities intersect with each other. Intersectionality is the interaction between gender, race, and other categories such as sexual orientation, age, disability, and so on, and the outcomes of these interactions in relation to power structures and oppression (Davis, 2008).

To include and analyse not only gender but other intersecting factors such as ethnicity, socioeconomic background, and so on is therefore vital, as it improves science and innovation and may also reveal sub-group differences (Schiebinger, 2017). This fact is also important as it clearly demarcates diversity from gender. While a proper gender balance contributes to diversity it does not replace it, and vice versa.

GENDER AND GENDER EQUALITY

It is also important to highlight that while the term 'gender' is used throughout this white paper, we use it to refer to 'gender equality' as opposed to the semantic meaning of the word 'gender'. Gender equality is an issue for both men and women, and both groups are affected in different ways and have needs and issues that must be addressed for gender equality to be achieved. However, for this particular subject area, that is to say STEM, nanotechnology, RRI and co-creation, the focus of the gender equality issue was the involvement of more women. Women are seriously underrepresented at all levels of STEM, and therefore it is this experience which this white paper is concerned with. Nevertheless, it is necessary to clarify that gender issues can also have an impact on men, and as we explore the issue of gender in this paper we do so in terms of gender equality.

CITIZENS AND CONSUMERS – ANOTHER FACET OF TAKING ON ROLES IN SOCIETY

However, identities are shaped by many more factors than the ones mentioned above, e.g. by political participation or participation in the economic system. In the contexts of product development and science, the roles the actors take up (e.g. of citizens and consumers) may fundamentally steer individual behaviour and relations to technology, from early adopters to reluctant users or objectors. Roles may also be affected by socioeconomic circumstances, levels of education, gender, ethnicity, age, and other demographics (Lee et al., 2006). Therefore, this may also shape how risky we consider nanotechnologies.

Citizens can engage in political or policy-related debates in different ways such as societal debates, environmental engagement, local initiatives etc., via mass media, social media, CSO membership, in addition to 'regular' political participation (i.e. voting).

As consumers, however, our perspectives and approaches are rather different. Consumers as customers are concerned with the safety of the products they purchase, with new and hopefully improved product properties, with price, availability and so on. The right to safety and the right to be informed are two of the most relevant rights for nano consumption, and they are linked to our consumer role (Throne-Holst and Strandbakken, 2009).

Today, however, consumers are not necessarily just individualised customers/buyers. The consumer role can be and has been politicised. One example is when groups of consumers use their collective purchasing power to boycott certain products for political-moral reasons, or – the other way around – endorse certain products. *"Political and ethical consumption and boycotts are not a new phenomenon. However, in late modernity, the complicated relationship between our role as consumers and citizens has been revived by the shift in political paradigm from government towards governance."* (Stø et al. 2008, p. 239)



Additionally, apart from political convictions as a moral guideline for consumption, we need to consider the fact that endusers/consumers are affected differently for a variety of reasons – be it their diverse biological condition, different behaviour in relation to a particular product (different user scenarios), or life circumstances.

POLICY RECOMMENDATIONS FOR BETTER CONSIDERATION OF GENDER EQUALITY, DIVERSITY, CULTURE AND COMMUNICATION

This white paper describes the policy recommendations that resulted from our analytical work in preparing the engagement methodology, and introduces the lessons learned in implementing that methodology in practice.

The five policy recommendations are:

- *Strengthen Gender Mainstreaming from the outset*
- *Include diversity from the outset*
- *Adopt a strategic engagement and a two-way communication effort*
- *Visualise future applications in everyday life contexts*
- *Challenge implicit discrimination and gender issues*

Explicitly discussing issues of gender, diversity, culture and communication in a white paper on nanotechnology innovation may enrich the discussion considerably, both on the level of research objects and participants and in terms of the research questions to be addressed. We will argue that connecting these issues allows for an increased innovation capacity and the opportunity to develop nanotechnology-enabled products that are better aligned to societal needs and values (for more information see white papers 1 and 2).⁸

⁸Further lessons concerning gender and diversity have also been explored in other EU projects such as RRItools: <https://www.rri-tools.eu/gender-equality#how-to> (30-06-2020).

RECOMMENDATION 1: STRENGTHEN GENDER MAINSTREAMING FROM THE OUTSET

There is a growing recognition of the benefits that the presence of female professionals in STEM brings, not least the fact that their mere presence may help to hasten the diversification of the sector by acting as role models for future entrants; nevertheless, women remain underrepresented at all levels (Sapleton and Takruri-Rizk, 2008).

To avoid the deficits within the scientific enterprise which result from the underrepresentation of women (Toumey, 2012), one good place to start is by adopting policies of gender mainstreaming. Gender mainstreaming is defined as *“the integration of a gender perspective into the preparation, design, implementation, monitoring and evaluation of policies, regulatory measures and spending programmes, with a view to promoting equality between women and men, and combating discrimination”* (European Institute for Gender Equality, 2016).

WHY?

By integrating sex and gender into all aspects of development, research and discussion, value is added by allowing diverse and new viewpoints or ideas, by ensuring innovation, excellence and quality in outcomes and enhancing sustainability, and by making research more responsive to social needs (Schiebinger, 2017). Probably the most well-known area where this applies is medicine, including pharmacological development, where the standard norm ‘human’ was historically defined in a non-diverse manner – typically as a young white male, an assumption that has extensive consequences for the medical treatment of the rest of the population (Health Canada 2013; Kim et al., 2010).

Another example, in the context of nanotechnology, is that men and women have differing attitudes towards the risks and benefits associated with nanotechnology; women are less enthusiastic about it and above all less willing to tolerate nano-related risk (Toumey, 2012).

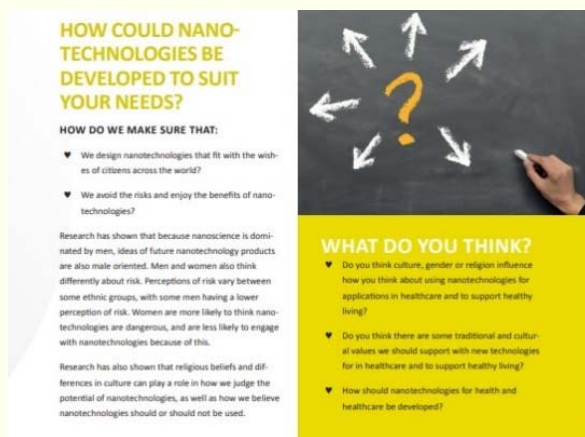
Gender mainstreaming was used in the multi-stakeholder engagement and co-creation process in GoNano to strengthen it from the very outset. By including this in the engagement methodology, the GoNano project provides both citizens and stakeholders with an opportunity to innovate in an informed and aware manner and to avoid the pitfalls caused by a group that is too homogeneous. We would therefore recommend including gender mainstreaming in all parts of any co-creation process.

Additionally, the recognition of participants’ individual and diverse inputs and viewpoints is crucial to implement gender equality, as well as allowing for the extension and reconsideration of societal norms (see Bogner, 2012). This implies that arguments and contents brought forward by the participants that are not in line with social norms or mainstream opinions are explicitly given a space. *“Deliberation norms become established which lead to the exclusion of those participants who cannot or do not want to fit in with those norms.”* (Bogner, 2012, p.519)

How?

For example, from the outset, the information leaflet specifically covered gender issues. The information given to the citizens before the workshop specifically encouraged participants to think along the lines of gender and diversity. The three information leaflets (GoNano Citizen's Meetings Information Material: Future Healthcare & Nanotechnologies, Future Food & Nanotechnologies, and Future Energy & Nanotechnologies) all included the following:

"Research has shown that because nanoscience is dominated by men, ideas of future nanotechnology products are also male oriented. Men and women also think differently about risk. Perceptions of risk



vary between some ethnic groups, with some men having a lower perception of risk. Women are more likely to think nanotechnologies are dangerous, and are less likely to engage with nanotechnologies because of this.

Research has also shown that religious beliefs and differences in culture can play a role in how we judge the potential of nanotechnologies, as well as how we believe nanotechnologies should or should not be used.

What do you think?

Do you think culture, gender or religion influence how you think about using nanotechnologies for application in [healthcare, food or energy]?

Do you think there are some traditional and cultural values we should support with new technologies for [healthcare, food or energy]?"

In GoNano, an effort was made to address gender both as biological sex and as a social construct. This was done to ensure that both physical representations and the ideals/expectations of behaviours exhibited by men or women and the value judgements made on those behaviours were included.

- A target was set to achieve a 50/50 gender balance in the citizen workshops and the stakeholder workshops as far as possible.
- For the stakeholder workshops, special effort was made to explicitly invite female experts. Because of the lower systemic representation of women in STEM, more efforts may be required to identify female experts with a specific area of expertise for which finding a male expert would be easier.
- The actual content of the workshop needs to reflect gender aspects – e.g. by including risk perception of nanotechnology, an area where gender divergence is noticeable (Toumey, 2012; Savath and Gage Brainard, 2013), in the topics under discussion.

However, within the workshop the discussions showed that participants were aware of gender issues and sometimes addressed them explicitly.

| | |
|--------------|--|
| Pilot Food | The effect of diversity was especially noted in the workshops run by the Czech partners, both for stakeholders and for citizens. As far as gender was concerned, the composition in all the groups was set so there would be a precise gender balance. From the perception of moderators there was no general difference observed between the participants, and if there were differences, the moderators would intervene to give equal space to all participants. The discussions were balanced due to good recruitment strategies and due to the work of moderators, who were able to provide space to most of the participants in an equal manner (in both citizen and stakeholder workshops); furthermore, due to a gender-balanced composition it may have been easier to steer the discussions in a more equal manner. |
| Pilot Health | In the Netherlands, during the debate on how to implement the diagnostic device for detecting diabetes type 2 at an early stage the business developer and other stakeholders were specifically asked whether they saw any differences between men and women in this regard. One stakeholder mentioned that women might be more used to a population screening, which was one approach to implementing the diagnostic device, as women between 50 and 70 get a 2-yearly population screening for breast cancer. Nevertheless, the stakeholders emphasised that more differences would be expected based on social economic status (SES), as diabetes type 2 is more common among people with a low SES. |
| Pilot Food | „The Czech citizen consultation showed that factors connected with accessibility, such as high price, could make the difference between customers who would buy or not buy a certain future product rather than gender, age or any other factor.“ |
| Pilot Health | In the Dutch citizen consultation about nanotechnologies for health, for example, in various groups a comparison was made between the diagnostic device and pregnancy tests. In these groups women often came up with this example and explained how home diagnostic tests, just like pregnancy tests, could empower patients. Both men and women further deliberated on the example. These discussions would probably be less likely to appear in groups with only men. |

RECOMMENDATION 2: INCLUDE DIVERSITY FROM THE OUTSET

As with gender, STEM, including nanotechnology, tends to suffer from a lack of diversity in all areas, including research, academia, and innovation and creation activities (European Commission, 2011). The lack of diversity in the nanotechnology field is an issue that, while not as widely acknowledged as the gender imbalance, is one that is of utmost importance and deserves to be highlighted just as much.

When a scientific community like the nanotechnology community lacks diversity, it is less likely to consider the needs and concerns of all those potentially affected by future nanotechnologies, especially those in populations that have been historically vulnerable (Savath and Gage Brainard, 2013). For example, a study on risk perception, gender and race found that while risk was judged as lower by men, it was consistently judged as much lower by white, well-educated, high-income, politically conservative males. Finucane et al. (2000) speculate that this result is because the world seems safer, and hazardous activities more beneficial, to white men than to other groups. Women and males of colour tend to be in a position of less power and control, benefit less from technologies and institutions, are more at risk from discrimination, and are therefore more cautious when judging risks (Finucane et al., 2000). Diversity is therefore helpful for more long-term and social benefit.

WHY?

The lack of diversity in the nanotechnology field is an issue that, while not as widely acknowledged as the gender imbalance, is also of utmost importance.

First, including diversity needs to be understood as a desirable societal norm: representatives of both sexes/all genders should be included.

Second, the concrete benefits of diversity are many. Teams have been proven to benefit from diversity, including gender, ethnicity, nationality, scientific discipline and work experience (Corley et al., 2016; Savath and Gage Brainard, 2013; Schiebinger, 2017; Nielsen et al., 2017). Encouraging diversity creates an innovation dividend for scientific organisations that leads to smarter, more creative teams with more new discoveries (Nielsen et al., 2017).

How?

Bearing this in mind, the GoNano methodology took a number of measures to ensure a balance when it came to diversity. However, ensuring diversity does not just mean replacing the word 'gender' with diversity, and several additional steps were taken (GoNano D2.1, 2018).

Based on the thorough investigation of gender and inclusion in the report 'Understanding the role of culture, gender and communication traditions, and their implications for engagement methodologies, communication and dissemination', (GoNano D1.2, 2018) efforts were made to enhance inclusion with regard to both the affected and unaffected public, with the goal of not being restricted to the somewhat homogeneous type of group that would have had prior interests in nanotechnology. This was done in order to allow for a more diverse discussion.

The workshops aimed at integrating different forms of expertise in constructive ways, thereby ensuring that not only a generic nanotechnology expert would be invited to participate. It was also crucial to include diversity in the recruitment sample and make it transparent.

For the Dutch citizen consultation on health, a diverse sample was recruited based on gender, age, and residential area (city vs. rural area) by distributing leaflets and invitations among different groups of people. Additionally, by recruiting via the website of Diabetesfonds and the regional hospital, the invitation was targeted at (diabetes) patients or family members of (diabetes) patients. The aim was to also include participants with different levels of education. However, this was difficult, as only people with relatively high levels of education responded to the invitation. Efforts were made to include less well-educated people as well, but they declined their invitations. When asked face-to-face why they had not responded to the invitation, they answered that they thought nanotechnology was a complex topic to which they would be unable to contribute. (Ilse Marschalek, 2018)

Also, the facilitation concept encouraged moderators to pose provocative questions to prompt thinking along different perspectives (see Recommendation 3).

These steps are all important to introduce diversity as often and as early as possible and to ensure that it actively contributes to and shapes nanotechnology development. Much like gender, including diversity is an ongoing process and needs to be continuously evaluated, critically reviewed so that new and different tactics can be introduced and improved where necessary. Reflection questions such as those proposed by the RRItools self-reflection tool⁹ or the NewHoRRizon thinking tool¹⁰ may support this process. Therefore, evaluation of processes needs to be oriented towards increasing diversity in order to make sure that these issues are taken up consistently and continuously within the different processes.

With regard to diversity, some of the workshops showed that rather than gender, it was education, age, and/or economic activity that provided noticeable impact. It is worth mentioning that age and education could be considered in the forefront in terms of impacting the results regarding diversity.

The composition of the Czech stakeholder workshop, which was dominated by highly educated and elder participants, may have resulted in what moderators saw as a more critical and passive debate about new ideas for nanotechnology products.

⁹<https://www.rri-tools.eu/self-reflection-tool> (30-06-2020).

¹⁰<https://newhorizon.eu/thinking-tool/> (30-06-2020).

| | |
|--------------|---|
| Pilot Food | <p>In the Czech citizen workshop, for citizens as potential customers, moderators had the impression that the economic situation of an individual and the cost of an application would be a number one factor that could impact the future acceptance of such products. During the stakeholder workshops, it was rather occupation or age that seemed to bring out different perspectives on the development of nanotechnology applications: For example, the businesses would be less risk-concerned than researchers, and PhD students would seem critical than senior researchers.</p> |
| Pilot Energy | <p>Lower age and a higher number of PhD students in the Spanish stakeholder workshop may have contributed to a more enthusiastic atmosphere during the workshops.</p> |

RECOMMENDATION 3: ADOPT A STRATEGIC APPROACH TO ENGAGEMENT AND A TWO-WAY COMMUNICATION EFFORT

WHY?

In order to interact with citizens, and to ensure that issues of gender and diversity described in Recommendations 1 and 2 are addressed, a specific and strategic effort targeting engagement and two-way communication is necessary. In order to reach all relevant parties, including society at large, it is necessary to make an effort to understand in what way to engage with citizens and how their opinions about nanotechnology are formed. Also, it is necessary to explain why an understanding of this is relevant for the broader society.

The extremely wide potential application of nanotechnology means its effects are difficult to predict. Alternatively, the citizen/consumer may not know that nanotechnology or nanomaterials are used in an item or product, as it may not be obvious (Throne-Holst and Strandbakken, 2009) and is not labelled with the exception of specific product groups and sectors (e.g. Cosmetics, Food, Biocides, Medical Devices, REACH; for further information see 'Risk governance and research & innovation priorities in Nanotechnologies', GoNano D5.1, 2018, p. 26). This can be interpreted as both a positive, in that there are no limits to how much and in how many ways we can benefit from nanotechnology, or a negative because we do not know how it may affect us. But how do citizens decide what to think of nanotechnology? By understanding this, the GoNano project can plan how best to approach specific groups and how to start a dialogue on their take on societal concerns relating to nanotechnology and future nanotechnology product development.

Decades of research into political communication (Lee et al., 2006) have shown that if information is presented in a certain way the level of accessibility of the presentation can change the intended audience's interpretation; however, interpretation of information will generally be based on pre-existing values, no matter how neutrally the information is presented or how much care is taken to maintain a balance (Scheufele, 2006). Also, trust in those communicating messages has also been shown to be key (Ho et al., 2010). Generally speaking, trust in relation to emerging technologies such as nanotechnology can be defined as a citizen's willingness to rely on the endorsement of experts such as scientists and regulators, and/or institutions such as the government, to manage risk associated with new and emerging technologies (Ho et al., 2010). It was therefore essential for the GoNano project to capture a breadth of opinions, including a representative demographic sample in citizen workshops and online engagement, as well as to ensure that questions important to different demographic groups were included as discussion points. This is partly because different demographic groups have different concerns, but also because the success of aligning nanotechnology research and innovation development with societal needs depends on the level at which all parts of society, and all those in the public discourse, are represented.

How?

By having an idea of how a lay person may come to form an opinion on nanotechnology, the next step is to ensure that the material the person is presented with, the way it is framed, and the extent to which attempts to engage the person in genuine conversation, are done appropriately and with differing cultural and intersecting social identities in mind.

The GoNano methodology adopted a number of strategies to reach participants with information, while bearing in mind the importance of communication style when doing so (GoNano D2.1, 2018):

- Strategic engagement from the beginning – tools were adapted to suit the level of engagement and vibrancy of discussion that was sought.

With regard to the citizen workshops, the GoNano team found that different parts of the co-creation process required a different kind of interaction. During the first part (inspiration), oral discussion was the most important way of communicating. This part was dominated by people with good oral skills, who happened, on this occasion, to be men, while more visual and manual skills were investigated during prototyping who happened to be women. A balance in different types of communication and discussion is important in order to get everyone's opinion.

- Two-way communication is very important – a conscious effort to engage fully with participants and speak *with* and not *at* them is crucial
- Emphasis on and time for opinion exchange during the workshops (participants listen to each other)
- Opinions on nanotechnology diverge among different demographic groups, and scientists are of course also influenced by predispositions. In order to hear these groups and listen to their thoughts and concerns about societal issues, the communication strategy therefore had a goal of mutual and ongoing engagement with each group.

RECOMMENDATION 4: VISUALISE FUTURE APPLICATIONS IN EVERYDAY LIFE CONTEXTS

WHY?

Due to their omnipresent but abstract character, nanotechnologies can be hard to explain and possibly even harder to imagine. They have been hailed as the basis of the next industrial revolution, transforming almost any field imaginable and providing rapid technological and societal progress. We can say of these two characteristics: 1) they are hard to imagine, and 2) the widespread and diverse nature of applications areas makes it a challenge to assess the future impact of nanotechnologies. Therefore, in order to connect development of nanotechnologies with issues of gender and diversity, we recommend situating visions of future applications of nanotechnologies in everyday life contexts.¹¹ Furthermore, situating future visions in a concrete context of use makes it easier for diverse participants in a co-creation process to have a conversation on nanotechnologies.

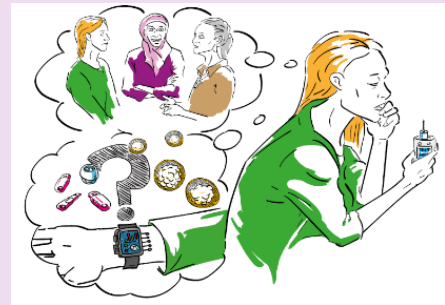
How?

In the GoNano project our concerns were about making nanotechnologies, as well as potential ethical and societal challenges, tangible to the participants in our co-creation processes. Gender and diversity issues were among the issues we wanted to illustrate so that the participants could start reflecting on them and providing feedback. Therefore, we developed scenarios that illustrated possible future applications of nanotechnologies in the areas of Health, Energy and Food.

Also, the information leaflet for each strand (healthcare, food, energy) contains several imaginary scenarios from everyday life in which nanotechnology is involved. The scenarios, while fictional and involving futuristic inventions, depict situations and conversations that mirror demographic and socioeconomic diversity, such as a conversation depicting different viewpoints between a man and a woman; income disparity; religious concerns; older people's thoughts; families; and younger single people. Below is an example from one of the leaflets.

¹¹The everyday life context to illustrate applications could differ according to the specific application area. The GoNano project aims to increase responsiveness to societal needs and values, and therefore focuses on the everyday life context of lay citizens (consumers?) in order to illustrate and stimulate reflection on the possible future ethical and societal impact of nanotechnologies. One could imagine that if the aim was to discover and explore issues in e.g. a clinical setting, it would be the everyday life context of clinicians or patients that would be used to stimulate reflection on possible impacts and issues.

In the cartoon about a 'home doctor', a visualisation was shown of a woman who tests for diabetes type 2 with a home-test device and who thinks about potential treatments. One of the issues she has with regenerative medicines is based on religious values, and in the cartoon a picture of three women is shown with one wearing a headscarf and one wearing a crucifix. They represent different religions.



This visualisation illustrates that at this point there are no analytical methods available that would enable the state authorities to completely detect the content of a food product, including the possible presence of nanoparticles. This was one of the citizens' needs most frequently expressed during the citizen consultation in the Czech Republic.

In the Spanish citizen consultation, the visualisation of doing the laundry tackles the issue of gender stereotyping by not associating housework chores with a particular gender and presenting both parents on an equal footing. The story also raises the question of financial inequality by introducing households with different income levels and the implications this can have for decisions.



RECOMMENDATION 5: CHALLENGE IMPLICIT DISCRIMINATION AND GENDER ISSUES

WHY?

With new technological or scientific developments come hype, hope and uncertainty. The hype and hope around nanotechnologies came in the form of expectations that it would enable the next industrial revolution, bringing with it hopes for progress in e.g. health technologies for diagnostics, therapeutics, and regenerative technologies, and finally uncertainty in the form of possible risks to human and environmental health. With expectations come visions of future scenarios of use. How will the new technology realise its potential? Visions include imagining who the users, consumers and producers will be and what the societal, political, ethical, legal and organisational context of the new technology looks like. Perhaps less obviously, visions also include assumptions with gender and diversity implications; however, these visions are subject to the creators' own prejudices as well as their imaginations. It is therefore important to envisage the potential actors, their reactions, and their behaviours and to reflect on and challenge *ex ante* existing assumptions or stereotypes in order to present more realistic visions.

How?

In the GoNano project, assumptions about gender and diversity were explicitly teased out by illustrating:

- How gender can influence one's thinking about risk
- How choices can be influenced by issues related to gender and diversity
- Inequalities in the distribution of new technologies
- Therapeutics that work better for some ethnic groups

Pilot Food

During stakeholder workshop 2 in the Czech Republic, moderators had the impression that in one expert group where there was a domination of female experts a slight increase in attention to the possible safety issues was apparent. However, at the same time this could have been caused by the topic itself – novel foods were perceived as the most 'unsafe' during the online consultation, and a further analysis of the results did not reveal any difference in gender. In the other expert groups, where female experts were representatives of research or business – as in the smart food packages discussion group – there was no apparent difference between the perceptions of (un)safety of the technology.

Pilot Health

At the citizen consultation about nanotechnologies for health, citizens discussed the development of regenerative medicines and the potential opposition based on religious values in this regard. One group of citizens agreed that religious values should never guide developments in healthcare. This same group also emphasised that if there was a danger to public health, health technologies should be made mandatory. They made a comparison with vaccinations, which some people do not want to take based on, amongst other things, religious values. In another group of citizens, one of the participants explicitly stated that she was not in favour of the development of regenerative medicines because of her Christian faith. The discussion on regenerative medicines in this group was much more nuanced than in the other group.

REFERENCES

- Bogner, A. (2012). The Paradox of Participation Experiments. *Science, Technology & Human Values*, 37(5), 506–527.
- Corley, E. A., Kim, Y., Scheufele, D. A. (2016). Scientists' ethical obligations and social responsibility for nanotechnology research. *Science and Engineering Ethics*, 22(1), 111-132.
- Davis, K. (2008). Intersectionality as buzzword: A sociology of science perspective on whatmakes a feminist theory successful. *Feminist Theory*, 9(1), 67-85.
- Deutsch, Francine M. (2007) Undoing Gender. *Gender & Society*, 21(1), 106-127.
- European Institute for Gender Equality (2016) What is gender mainstreaming? Luxembourg: Publications Office of the European Union.
- European Commission (2011) Toolkit Gender in EU-funded research. Luxembourg: Publications Office of the European Union.
- GoNano D1.1 (2018) Deliverable 1.1: Building on the state-of-the-art: ex-post evaluation on mutual learning. Brussels: GoNano project.
- GoNano D1.2 (2018) Deliverable 1.2: Understanding the role of culture, gender and communication traditions, and their implications for engagement methodologies, communication and dissemination. Brussels: Gonano project.
- GoNano D2.1. (2018). Deliverable 2.1: Method and manuals for the pilot studies: towards a GoNano co-creation approach. Brussels: GoNano project.
- GoNano D3.2. (2019). Deliverable 3.2: Citizen needs and values in relation to nanotechnology in food, energy and health: A report from citizen workshops in the Czech Republic, Spain and the Netherlands. Brussels: GoNano project.
- GoNano D4.2. (2019). Deliverable 4.2: Working paper on the designs and outcomes of workshop round 1. Brussels: GoNano project.
- GoNano D4.4 (2020) Deliverable 4.4: Final report on the insights and lessons from the engagement activities. Brussels: GoNano project.
- GoNano D5.1. (2018). Deliverable 5.1: Risk governance and research & innovation priorities in nanotechnologies. Brussels: GoNano project.
- Health Canada (2013) Guidance Document: Considerations for Inclusion of Women in Clinical Trials and Analysis of Sex Differences [Online]. Available: <http://www.hc-sc.gc.ca/dhp-mps/prodpharma/applic-demande/guide-ld/clini/...> [Accessed 18 May 2018].

- Ho, S. S., Scheufele, D. A., Corley, E. A. (2010). Making sense of policy choices: understanding the roles of value predispositions, mass media, and cognitive processing in public attitudes toward nanotechnology. *Journal of Nanoparticle Research*, 12(8), 2703-2715.
- Ilse Marschalek, *Public Engagement in Responsible Research and Innovation. A Critical Reflection from the Practitioner's Point of View*. Saarbrücken: Südwestdeutscher Verlag für Hochschulschriften, 2018, p. 94.
- Kim, A.M., Tingen, C.M., Woodruff, T.K. (2010). Sex bias in trials and treatment must end. *Nature*, 465(7299), 688-689.
- Lee, C.J., Scheufele, D. A. (2006). The influence of knowledge and deference toward scientific authority: A media effects model for public attitudes toward nanotechnology. *Journalism and Mass Communication Quarterly*, 83(4), 819-834.
- Nielsen, M.W., Alegria, S., Börjeson, L., Etzkowitz, H., Falk-Krzesinski, H.J., Aparna, J., Leahey, E., Smith-Doerr, L., Woolley, A.W., Schiebinger, L. (2017). Gender diversity leads to better science. *Proceedings of the National Academy of Sciences of the United States of America*, 114(8), 1740-1742.
- Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society, to science for society, with society. *Science and Public Policy*, 39, 751-760.
- Sapleton, N., Takruri-Rizk, H. (2008). The Gender Subtext of Science, Engineering, and Technology (SET) Organizations: A Review and Critique. *Women's Studies*, 37(3), 284-316.
- Savath, V., Gage Brainard, S. (2013). Managing nanotechnology risks in vulnerable populations: A case for gender diversity. *Review of Policy Research*, 30(5), 549-565.
- Scheufele, D. A. (2006). Five lessons in nano outreach. *Materials Today*, 9(5), 64.
- Schiebinger, L. (2017). Expert Paper: Gender-responsible research and innovation for small and medium-sized enterprises: Nanotechnology, ICT and healthcare. Vienna: COMPASS/European Union.
- Strand, R. S., Jack; Bauer, Martin W.; Hogan, E.; Revuelta, G.; Stagl, S. (2015). Indicators for promoting and monitoring Responsible Research and Innovation. Report from the Expert Group on Policy Indicators for Responsible Research and Innovation. E. Commission. Brussels.. Online: http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf [2020-01-20]
- Stø, E., Throne-Holst, H., Strandbakken, P., & Vittersø, G. (2008). Review: a multi-dimensional approach to the study of consumption in modern societies and the potential for radical sustainable changes. *System innovation for sustainability 1, Perspectives on Radical Changes to Sustainable Consumption and Production*, 234-254.
- Toumey, C. (2012). Does nanotech have a gender? *Nature Nanotechnology*, 7(7), 412.



Throne-Holst, H. and Strandbakken, P. (2009). "Nobody Told Me I was a Nano-Consumer:" How Nanotechnologies Might Challenge the Notion of Consumer Rights. *Journal of Consumer Policy* 32(4):393-402. DOI: 10.1007/s10603-009-9114-9.

World Health Organisation. (2010). *Gender, women and primary health care renewal: A discussion paper*. Geneva: World Health Organisation.



4. ANNEXES



Annex 1: Data management plan

The present report is a synthesis of relevant literature on the respective topics of the white papers and experiences from the GoNano pilot studies.

The white papers are based on the collection and analysis of publicly available information from: scientific and non-scientific publications, as well as GoNano deliverables.

All information sources are referenced and listed in the respective white papers.


No further data was collected, stored or analysed for this report.

Annex 2: Template for public consultation feedback as provided on the GoNano homepage

Template for comments on **Globing White Papers**

Plases provide us with feedback until
April 30th, 2020

Please send it to:
whp@papers.dfbzw.eu



Annex 2: Template for providing feedback and comments for White Paper consultation

Please indicate: Consider my feedback for...

☐


White Paper 1:
"Responsiveness in practice: Aligning Nanotechnology Research and Innovation with societal needs"

☐

White Paper 2:
"Co-creation in practice: Setting the scene for nanotechnology in Research and Innovation"

☐

White Paper 3:
"The importance of gender and diversity in nanotechnology Research and Innovation"


| Template for comments on Cobanco White Papers <div style="display: flex; justify-content: space-between;"> <div> Please provide us with feedback until April 30th, 2020 </div> <div> Please send to whitpapers@cobanco.at </div> <div>  </div> </div> | | |
|---|------------------|---|
| NAME | General Comments | If possible: Suggested Change – Solutions |
| Please add name and/or your organization as background. If you like to stay anonymous indicate ANON/IM | | (we will number them in an extra document and tell why not taken on if necessary) |
| | | |

[illegible]

Annex 3: Received feedback on the white papers through the public consultation

Please note: GoNano has received feedback on white paper 2: “Co-creation in practice: Setting the scene for nanotechnology in Research and Innovation”. white paper 1 and 3 have received no detailed feedback. Where feedback was received in different form than the template, the most important points are subsumed.

| white paper 2: “Co-creation in practice: Setting the scene for nanotechnology in Research and Innovation” | | | |
|---|--|---|--|
| NAME | General Comments | If possible: Suggested Change – Solutions (we will number them in an extra document and tell why not taken on if necessary) | Taken up (yes / no) If no: reasons why not. |
| Saira Raza (Workshop Participant) | Although I agree that cultures are what need to change, the title of recommendation 6 (Create a culture of co-creation) reads a bit vague and perhaps not actionable | <p>In the abstract for this recommendation you mention mainstreaming and restructure so I wonder if what you are asking for is to ‘Mainstream co-creation practices’ - across publicly funded projects (research, civic and industrial) in the same way that representation, inclusion and sustainability is mainstreamed?</p> <p>Maybe it’s a bit early for this as co-creation practices may need more fleshing out and</p> | Yes: title was kept, but thought was integrated in first paragraph |

| | | | |
|--|--|---|--|
| | | evaluation themselves but if we're going to start we might as well start with an important field such as nanotech because it covers so much, will affect many people and is relatively new so it may be easier to design out obstacles before they establish. | |
| <p>Dr. Corina Ross</p>  | Page 20: "On one hand, the nutrition/novel foods application area was perceived as the most promising area connected to many expectations" (co-creation pilot on food, Czech Republic) | I can estimate that in the condition of lack of protective medical clothes, the price for nonwovens defeated the gold price. | No. Reason: The estimation of promises in the food pilot relate only to developments in the food sector. Acknowledging that there may be a variation of assessments regarding market developments under changing conditions, please note that the pilots were carried out before Corvid-19. So, developments in relation to this were necessarily not taken into account. |
| | Page 23: Figure 5: Nanotech Research and Development priorities, Column Health – lack of protective nonwoven material (e.g. facial masks) and antibacterial nanofilters for air conditioning | <p>Please see bibliography.</p> <p>https://www.academia.edu/29232416/Nanofibers_From_Natural_and_Inorganic_Polymers_Via_Electrospinning</p> <p>https://www.inovenso.com/nanofiber-facemask/</p> | No. Reason: Due to recent developments (spreading of Corvid-19), these priority settings may have varied since the pilot studies. |

| | | | |
|--------------------------------------|--|--|---|
| Hilary Sutcliffe (Society Inside) | Missing business case: I see recommendations, but not a really compelling 'business case' or many examples of (a) the problem being solved and (b) success stories where it has really worked. | | The GoNano business case will be discussed in a separate deliverable and will be an emphasis in the industry briefs. |
| | Failing to get the balance of (a) reflecting all the work and (b) the language and design which will be effective in engaging the potential target audience in the findings. This may be the long document, with a short and punchy one attached, so that could be OK, but I can't see a company ploughing through this really. | | Yes: these short documents will be the policy and industry briefs. |
| | Overstraining of resources: You are asking a huge and unrealistic amount from them, which will put them off, i.e. <i>'map the state-of-the-art of research in the specific fields.'</i> | | No. Reason: white papers should offer a whole variety of suggestions; even if it is not possible to take them up, they indicate the aspirations that such co-creation processes aim for. |

| | | | |
|--|---|--|---|
| | <p>Straighten and clarify the language: The language is somehow woolly, like it has been written by committee. But it is also to the significant detriment of the impact of the project findings.</p> | | <p>Yes: language aimed to be straightened throughout the white papers; policy and industry briefs shorter and straight to the point</p> |
|--|---|--|---|

Annex 4: Distribution efforts by the GoNano consortium to engage people to provide their feedback and comments

| | |
|----------|--|
| AIRI | <p>Broad, but targeted communication strategy: shared the invitation to comment</p> <ul style="list-style-type: none"> • Circulation of draft white papers and news of the consultation to a large part of our mailing list (>4500 contacts) • Feedback: at least some 150 people have downloaded the reports (the number it is likely higher, this only refers to the direct link). |
| CIEL | <p>Broad and targeted communication strategy:</p> <ul style="list-style-type: none"> • Shared the invitation multiple times on social media (Linkedin and Twitter) • Shared it with a select group of scientists (mostly working on nano tox and ecotox) • Shared with people in ILO (International Labour Organization) working on the theme of nano, innovation and workers' rights |
| DBT | <p>Broad, but targeted communication strategy</p> <ul style="list-style-type: none"> • Shared the invitation in DBT newsletter that goes out to about 1000 recipients • shared the news on DBT social media accounts (690 followers on Twitter and 1052 followers on LinkedIn) • sharing invitation together with the updates on the final conference to the speakers • shared invitation on the GoNano Twitter (290 followers). • sent the consultation directly to members of the DBT stakeholder board, which consists of 48 representatives of Danish universities, business networks and civil society – and interest organisations. |
| DPF | <p>Targeted communication strategy: specifically reached out to some experts from our network and recently graduated students to comment.</p> |
| EIWH | <p>Broad communication strategy: broadly shared the invitation to comment.</p> <ul style="list-style-type: none"> • Circulation of the invite on Twitter and Facebook accounts and on LinkedIn. • Inclusion of the invite in the EIWH Members newsletter. |
| ITA-OeAW | <p>Broad communication strategy: broadly shared the invitation to comment.</p> <ul style="list-style-type: none"> • Twitter from the ITA account (@technikfolgen) • Shared on the ITA project homepage • Shared on the ITA homepage news feed |
| OSLO-MET | <p>Targeted communication strategy: specifically reached out to some experts to comment.</p> |
| RMIT | <p>Mixture of targeted and broad communication strategy: specifically reached out to stakeholders as well as broadly shared the invitation to comment.</p> <ul style="list-style-type: none"> • stakeholders from the workshops in Barcelona (34 in total) and the winter school participants (36 in total). • twitter (...) from the RMIT Europe account. |
| TC Cas | <p>Mixture of targeted and broad communication strategy: specifically reached out to key stakeholders as well as broadly shared the invitation to comment.</p> <ul style="list-style-type: none"> • sent an offer to key Czech stakeholders to give comments to one of the GoNano white papers. |

| | |
|----|---|
| | <ul style="list-style-type: none"> • twitter (@tech4czech and @TC_AVCR accounts) • LinkedIn (Czech team accounts) |
| UT | Targeted communication strategy: specifically reached out to some experts and participants of the co-creation workshops to comment. |